Naval Education and
Training Command

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Manual

UNITED STATES NAVY

Fire Control Technician B 3 & 2 (POSEIDON)

Although the words "he," "him," and "his" are used sparingly in this manual to enhance communication, they are not intended to be gender driven nor to affront or discriminate against anyone reading *Fire Control Technician B 3 & 2, (POSEIDON)*, NAVEDTRA 10211-C.

Naval Education And Training Program Development Center

FIRE CONTROL TECHNICIAN B 3 & 2 (POSEIDON)

NAVEDTRA 10211-C

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1985 Edition Prepared by
FTBC(SS) John A. Huck

THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

CONTENTS

CHAPTER Page

1. POSEIDON Fleet Ballistic Missile Weapon System 1-1
2. Inertial Devices and Mk 3 Guidance 2-1
3. POSEIDON Fire Control System Mk 88 Mod 1 3-1
4. Digital Geo-Ballistic Computer and Magnetic Disk File 4-1
5. POSEIDON Weapon System Operation 5-1
6. Test Equipment and Maintenance......................... 6-1
7. POSEIDON Missile and Missile Launching System 7-1
8. Optical Alignment Group 8-1
9. Administrative Procedures 9-1

APPENDIX

I. Glossary AI-1

INDEX I-1

NOTICE

Navy training and advancement system information related to your rating is contained in the FTB 3 & 2 (TRIDENT), RTM, Chapter 1, titled *Fire Control Technician Ballistic Missile (FTB)*.

READEX FICHE

best copy available

NOTE

The occupational standards listed were current at the time this RTM was printed but may have changed. You should contact your ESO for a copy of the up-to-date occupational standards.

FIRE CONTROL TECHNICIAN (BALLISTIC MISSILE FIRE CONTROL) (FTB) OCCUPATIONAL STANDARDS

NUMBER	OCCUPATIONAL STANDARD
FIRE CONTROL TECHNICIAN (BALLISTIC MISSILE FIRE CONTROL) THIRD CLASS (FTB3)	
11 DAMAGE CONTROL	
11452	SERVE AS A TEAM MEMBER DURING POST ACCIDENT AND/OR INCIDENT EVOLUTIONS INVOLVING FBM WEAPONS
14 ELECTRONICS MAINTENANCE	
14581	ADJUST, ALIGN, AND CALIBRATE BASIC ELECTRONIC CIRCUITS
14582	INTERPRET THE PRINCIPLES OF THE FOLLOWING CIRCUITS: A. INTEGRATORS B. DIFFERENTIATORS C. LIMITERS D. CLAMPERS E. MULTIVIBRATORS F. AMPLIFIERS G. RESONANT CIRCUITS H. POWER SUPPLIES I. OSCILLATORS
14639	REMOVE AND CONNECT CHASSIS WIRING, MULTICONDUCTOR CABLE AND TRANSFORMER LEADS
17 WEAPONS MAINTENANCE	
17326	IDENTIFY BASIC PURPOSES AND FUNCTIONS OF MISSILE, LAUNCHER, FIRE CONTROL, NAVIGATION, AND SHIP SUPPORT SUBSYSTEMS

NUMBER	OCCUPATIONAL STANDARD
	FIRE CONTROL TECHNICIAN (BALLISTIC MISSILE FIRE CONTROL) THIRD CLASS (FTB3)—CONTINUED
	17 WEAPONS MAINTENANCE—CONTINUED
17430	PERFORM, UNDER LIMITED SUPERVISION, TESTS, ADJUSTMENTS, AND CALIBRATION IN ACCORDANCE WITH PROCEDURAL DOCUMENTATION ON THE FOLLOWING: A. FIRE CONTROL SYSTEM AND SUPPORT SUBSYSTEMS B. GUIDANCE SYSTEM, POWER SUPPLIES, AND TEST FACILITIES C. OPTICAL ALIGNMENT EQUIPMENT D. ASSIGNED MISSILE TEST AND READINESS EQUIPMENT E. SHIP SUPPORT SUBSYSTEMS
17431	PERFORM, UNDER LIMITED SUPERVISION, DOCUMENTED FAULT ISOLATION PROCEDURES AND REPLACE FAULTY COMPONENTS ASSOCIATED WITH: A. FIRE CONTROL SYSTEM AND SUPPORT SUBSYSTEMS B. GUIDANCE SYSTEM, POWER SUPPLIES, AND TEST FACILITIES C. OPTICAL ALIGNMENT EQUIPMENT D. ASSIGNED MISSILE TEST AND READINESS EQUIPMENT E. SHIP SUPPORT SUBSYSTEMS
	18 TEST EQUIPMENT
18379	USE GENERAL PURPOSE TEST EQUIPMENT REQUIRED BY PROCEDURAL DOCUMENTATION
	24 ELECTRICAL MAINTENANCE
24530	INTERPRET THE PRINCIPLES OF ELECTROMAGNETIC INDUCTION AS APPLIED TO TRANSFORMERS, MOTORS, AND GENERATORS
	26 ANALOG/DIGITAL COMPUTER
26217	IDENTIFY BASIC DIGITAL CIRCUITS, INCLUDING RECOGNITION OF COMPONENTS AND THEIR FUNCTION
26250	INTERPRET DISPLAYS AND PRINTOUTS OF COMPUTERS AND PERIPHERAL EQUIPMENT
26251	IDENTIFY DIGITAL LOGIC SYMBOLS
26275	LOAD PROGRAMS IN COMPUTER

NUMBER	OCCUPATIONAL STANDARD
FIRE CONTROL TECHNICIAN (BALLISTIC MISSILE FIRE CONTROL) THIRD CLASS (FTB3)—CONTINUED	
28 TECHNICAL DRAWINGS	
28031	IDENTIFY ELECTRICAL, ELECTRONIC, AND MECHANICAL COMPONENT PARTS BY REFERENCE TO ASSOCIATED CIRCUITS DIAGRAMS AND MECHANICAL DRAWINGS USING MILITARY STANDARD CODING
28335	TRACE SIGNAL FLOW PATHS IN THE FOLLOWING: A. EQUIPMENT AND/OR SUBSYSTEM TECHNICAL MANUALS B. FBM WEAPON SYSTEM ELECTRICAL DIAGRAMS
29 MECHANICAL MAINTENANCE AND OPERATION ORDNANCE EQUIPMENT	
29261	LUBRICATE WEAPONS EQUIPMENT
29262	INSPECT ROTATING MACHINERY
35 ADMINISTRATION	
35451	IDENTIFY DATA LOGGING REQUIREMENTS FOR THE FBM WEAPONS SYSTEM, SUBSYSTEMS, AND EQUIPMENTS AS REQUIRED BY PROCEDURAL DOCUMENTATION
35453	READ ELAPSED TIME METERS AND PREPARE REPORTS
46 PUBLICATIONS	
46403	ENTER CHANGES IN PUBLICATIONS
46407	IDENTIFY THE ORGANIZATION, CONTENT, AND USE OF WEAPON SYSTEM PUBLICATIONS AND DOCUMENTS
51 MAINTENANCE PLANNING AND/OR QUALITY ASSURANCE	
51011	COMPLETE MAINTENANCE DATA FORMS FOR: A. COMPLETED MAINTENANCE ACTIONS (MAF) B. DEFERRED MAINTENANCE ACTIONS C. WORK REQUESTS
51026	USE MAINTENANCE REQUIREMENT CARDS (MRC)
51269	INTERPRET PROCEDURES OF THE CALIBRATION RECALL PROGRAM
51270	INTERPRET THE PURPOSE OF THE QUALITY ASSURANCE PROGRAM
51480	PREPARE TROUBLE AND FAILURE REPORTS

NUMBER	OCCUPATIONAL STANDARD
FIRE CONTROL TECHNICIAN (BALLISTIC MISSILE FIRE CONTROL) THIRD CLASS (FTB3)—CONTINUED	
54 LOGISTICS SUPPORT	
54903	ORDER REPAIR PARTS AND SPECIAL TOOLS REQUIRED FOR INSTALLED EQUIPMENT MAINTENANCE USING ALLOWANCE PARTS LISTS AND ALLOWANCE EQUIPAGE LISTS
54906	PREPARE AND DOCUMENT TURN-IN OF REPAIRABLES
77 SECURITY	
77280	APPLY PERTINENT NUCLEAR WEAPONS SECURITY REGULATIONS RELATED TO ASSIGNED DUTIES WITHIN THE FBM WEAPON SYSTEM
89 WEAPON SYSTEM OPERATION	
89007	PERFORM, UNDER LIMITED SUPERVISION, NORMAL AND CASUALTY OPERATION DURING ALL CONDITIONS OF READINESS OF THE: A. FIRE CONTROL SYSTEM AND SUPPORT SUBSYSTEMS B. GUIDANCE SYSTEMS, POWER SUPPLIES, AND TEST FACILITIES C. OPTICAL ALIGNMENT EQUIPMENT D. ASSIGNED MISSILE TEST AND READINESS EQUIPMENT
89008	IDENTIFY INDICATIONS WHICH WILL OCCUR DURING NORMAL OPERATION UNDER ALL CONDITIONS OF READINESS OF THE FIRE CONTROL SYSTEM, SUBSYSTEMS, AND EQUIPMENT
92 ELECTRO/MECHANICAL MAINTENANCE	
92367	INTERPRET THE PRINCIPLES AND APPLICATIONS OF THE FOLLOWING ELECTROMEHCANICAL DEVICES: A. INERTIAL COMPONENTS B. SYNCHROS AND SERVO SYSTEMS C. RELAY DEVICES D. SOLENOIDS
94 MECHANICAL MAINTENANCE	
94770	USE AND MAINTAIN COMMON HANDTOOLS AND SPECIAL TOOLS
94775	USE AND MAINTAIN TORQUE WRENCHES

NUMBER	OCCUPATIONAL STANDARD
FIRE CONTROL TECHNICIAN (BALLISTIC MISSILE FIRE CONTROL) SECOND CLASS (FTB2)	
14 ELECTRONICS MAINTENANCE	
14112	ISOLATE AND REPLACE DEFECTIVE CIRCUIT COMPONENTS
14789	INTERPRET THE PRINCIPLES OF: A. MAGNETIC AMPLIFIERS B. MODULATORS C. DEMODULATORS
16 ORDNANCE AND MISSILE HANDLING	
16336	TRANSFER FBM GUIDANCE ASSEMBLIES FOR CHECKOUT AND STORAGE
17 WEAPONS MAINTENANCE	
17339	EFFECT ALTERATIONS (SPALTS, ORDALTS, SHIPALTS) TO THE FBM WEAPON SYSTEM AND APPLICABLE SUPPORT SUBSYSTEMS
17356	ANALYZE WEAPON SYSTEM TEST RESULTS
17432	PERFORM TESTS, ADJUSTMENTS, AND CALIBRATION IN ACCORDANCE WITH PROCEDURAL DOCUMENTATION ON THE FOLLOWING: A. FIRE CONTROL SYSTEM AND SUPPORT SUBSYSTEMS B. GUIDANCE SYSTEM, POWER SUPPLIES, AND TEST FACILITIES C. OPTICAL ALIGNMENT EQUIPMENT D. ASSIGNED MISSILE TEST AND READINESS EQUIPMENT E. SHIP SUPPORT SUBSYSTEMS
17433	PERFORM FAULT ISOLATION PROCEDURES AND REPLACE OR BYPASS FAULTY EQUIPMENT OR COMPONENTS IN ACCORDANCE WITH AUTHORIZED MAINTENANCE POLICIES ON THE FOLLOWING: A. FIRE CONTROL SYSTEM AND SUPPORT SUBSYSTEMS B. GUIDANCE SYSTEM, POWER SUPPLIES, AND TEST FACILITIES C. OPTICAL ALIGNMENT EQUIPMENT D. ASSIGNED MISSILE TEST AND READINESS EQUIPMENT E. SHIP SUPPORT SUBSYSTEMS
18 TEST EQUIPMENT	
18039	INSPECT GENERAL AND SPECIAL PURPOSE TEST EQUIPMENT AND PERFORM AUTHORIZED MAINTENANCE

NUMBER	OCCUPATIONAL STANDARD
FIRE CONTROL TECHNICIAN (BALLISTIC MISSILE FIRE CONTROL) SECOND CLASS (FTB2)—CONTINUED	
24 ELECTRICAL MAINTENANCE	
24510	PERFORM WIRE WRAP OPERATIONS
24559	PERFORM MAINTENANCE ON ASSIGNED POWER SOURCES AND CONTROL DEVICES
24560	REPLACE AND REPAIR MULTI-ELEMENT JACKS, PLUGS AND MULTI-CONDUCTOR CABLES
26 ANALOG/DIGITAL COMPUTER	
26254	OPERATE COMPUTER IN ALL MODES
26274	WRITE A COMPUTER PROGRAM
28 TECHNICAL DRAWINGS	
28376	TRACE SIGNAL FLOW PATHS IN FORM ABLES
28377	USE CIRCUIT DIAGRAMS IN SOURCE DOCUMENTATION
35 ADMINISTRATION	
35455	IDENTIFY FBM WEAPONS SYSTEM MICROFORM DRAWING FILE, INCLUDING CONTENT, PURPOSE, USAGE AND AUTHORITY
35483	MAINTAIN REQUIRED LOGS AND RECORDS
46 PUBLICATIONS	
46626	MAINTAIN TECHNICAL LIBRARY OF OP'S, OD'S, SWOP'S, TECHNICAL MANUALS, AND OTHER DOCUMENTATION
51 MAINTENANCE PLANNING AND/OR QUALITY ASSURANCE	
51114	COMPLETE PLANNED MAINTENANCE SUB-SYSTEM (PMS) FEEDBACK REPORTS
51272	COMPLY WITH QUALITY ASSURANCE PROCEDURES
51273	CARRY OUT THE PROCEDURES OF THE CALIBRATION RECALL PROGRAM FOR TEST EQUIPMENTS

NUMBER	OCCUPATIONAL STANDARD
FIRE CONTROL TECHNICIAN (BALLISTIC MISSILE FIRE CONTROL) SECOND CLASS (FTB2)—CONTINUED	
54 LOGISTICS SUPPORT	
54907	INVENTORY INSTALLED EQUIPMENT AND VERIFY SPARE PART SUPPORT IN COSAL
54909	POST CHANGES AND ADDITIONS TO COSAL
77 SECURITY	
77281	ENFORCE PERTINENT NUCLEAR WEAPONS SECURITY REGULATIONS RELATED TO ASSIGNED DUTIES WITHIN THE FBM WEAPON SYSTEM
89 WEAPON SYSTEM OPERATION	
89009	PERFORM NORMAL AND CASUALTY OPERATION DURING ALL CONDITIONS OF READINESS OF THE: A. FIRE CONTROL SYSTEM AND SUPPORT SUBSYSTEMS B. GUIDANCE SYSTEMS, POWER SUPPLIES AND TEST FACILITIES C. OPTICAL ALIGNMENT EQUIPMENT D. ASSIGNED MISSILE TEST AND READINESS EQUIPMENT
89010	IDENTIFY INDICATIONS WHICH WILL OR MAY OCCUR DURING NORMAL AND CASUALTY OPERATIONS UNDER ALL CONDITIONS OF READINESS OF THE FIRE CONTROL SYSTEM, SUBSYSTEMS, AND EQUIPMENT

CHAPTER 1

POSEIDON FLEET BALLISTIC MISSILE WEAPON SYSTEM

INTRODUCTION

The POSEIDON Fleet Ballistic Missile (FBM) weapon system constitutes a military strength of such magnitude that it acts as a major deterrent to attack by any aggressor. It is a submarine weapon system that can operate in any navigable waters with an almost unlimited cruising range, in all weather, from both surface and submerged positions.

Each weapon system can launch 16 **POSEIDON missiles. Reentry bodies (RB's),** with nuclear capability, are thereby placed in ballistic trajectory, able to reach single or multiple targets that might be difficult or impossible to reach by conventional air attack techniques.

POSEIDON MISSILE WEAPON SYSTEM CONCEPTS

The concept of firing POSEIDON missiles from a submerged or surfaced submarine presents certain problems not encountered when firing from a shore-based, fixed launching pad. Movement of the submarine imparts motion to the missile that must be taken into account. The exact location of the submarine, relative to the target, must be determined to ensure that accurate data is inserted into the missile guidance computer. An initial energy source must be provided to eject the missile from the missile tube. Prior to launch, certain tests must be performed to determine the overall operational readiness of the missile.

The fleet ballistic missile weapon system is designed to solve these problems. The submarine is equipped with facilities to provide optimum stability for its use as a launching platform. The navigation system continuously determines the geographic location of the submarine and provides instantaneous ship position, attitude, and velocity data to the fire control (FC) system.

The FC system uses this data to modify precalculated guidance data, and also erects and aligns the stable platform to provide directional reference during powered flight.

Missile test and readiness equipment monitors circuits within the missile and performs programmed tests, checkout, and preflight operations to determine missile readiness conditions.

The launching system, through an ejection process using high-pressure gas, enables a flameless missile launch with rocket motor ignition occurring at a safe height above the submarine.

The Mk 3 guidance system used with POSEIDON missiles is a completely inertial system. Pertinent information indicating target bearing, missile velocities, attitude, and other necessary guidance constants is read into the guidance system by FC prior to launch. Once the missile is in flight, the guidance system requires no external control or data to maintain the missile along its computed trajectory.

The POSEIDON C3 Missile is a two-stage, intermediate range, ballistic missile that delivers multiple reentry bodies (RB's) to selected targets. During the guided portion of missile flight, each RB is given the precise velocity and attitude to enable it to free fall from a point in space to a selected target without additional guidance or power.

If a missile could be designed so that it would always perform identically with respect to thrust, weight, and aerodynamics, and could be affected only by predictable wave, wind, and other atmospheric conditions, we could assume a standard missile. Such a missile would require a relatively simple guidance system and would fly a standard trajectory. This ideal situation would enable us to precalculate missile position and velocity for any point along the trajectory as a function of time. A completely programmed flight could be determined prior to launch, with REB separation commanded by a timer.

To expect a missile and its flight environment to be standard, however, is not realistic. Each missile flight will differ from every other missile flight because variations in thrust, weight, aerodynamics and flight environment will affect the standard and total time of flight. During powered flight, the guidance system measures nongravitational accelerations of the missile and computes the gravitational acceleration. The guidance system uses this information (plus flight parameters and calibration information for guidance system correctable errors that are read in prior to launch) to compute a flight program. The flight program then controls missile flight along a computed path until each RB achieves the proper attitude and velocity for RB release.

POSEIDON WEAPON SYSTEM ORGANIZATION

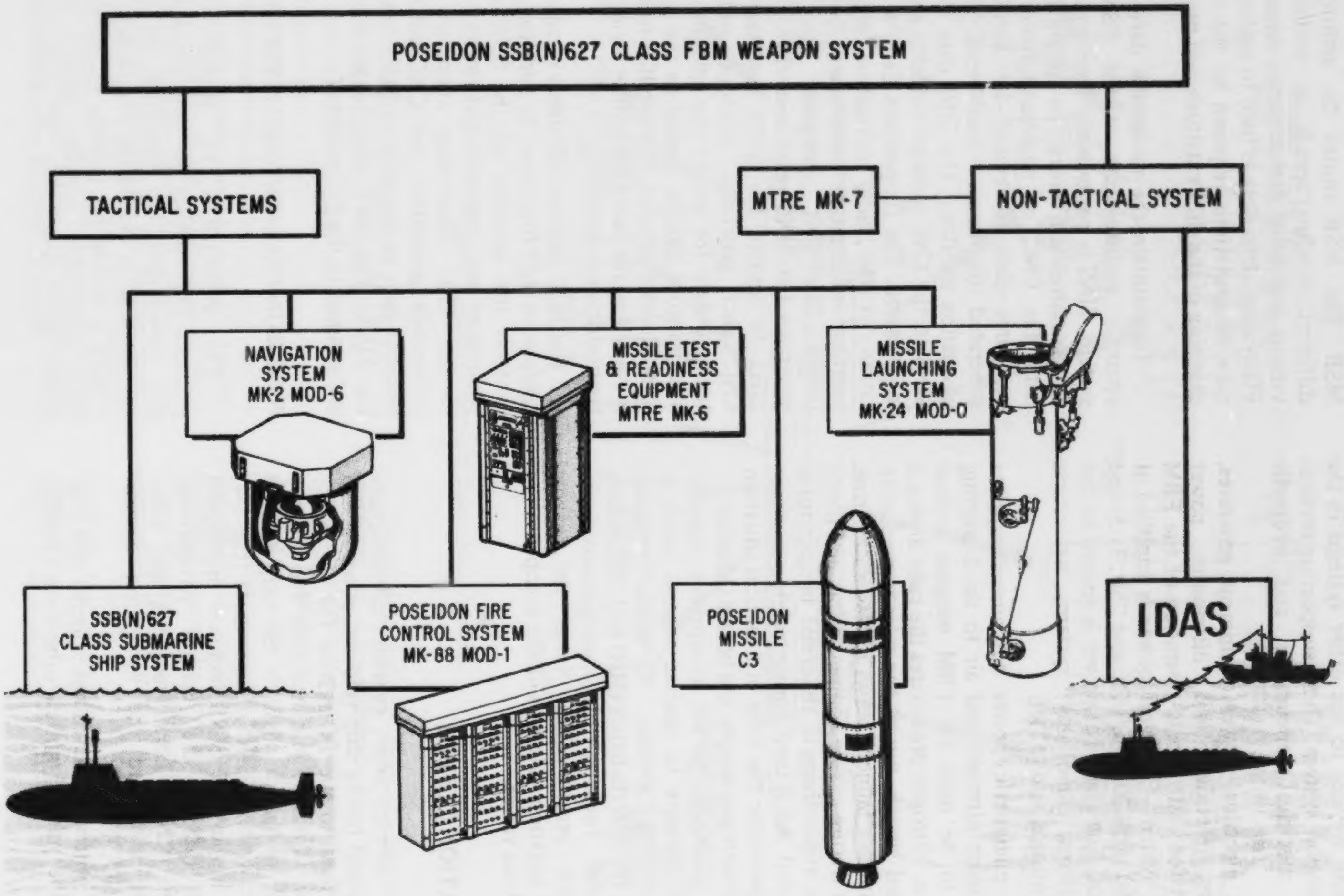
The POSEIDON FBM weapon system is comprised of six tactical systems and two nontactical systems (fig. 1-1).

The tactical systems are as follows:

1. Ship system
2. Navigation system
3. Mk 88 Mod 1 Fire Control System
4. C3 missile system
5. Missile Test and Readiness Equipment (MTRE Mk 6)
6. Missile launching system

The nontactical systems are the Integrated Data Acquisition System (IDAS) and Missile Test and Readiness Equipment Mk 7.

The interface of data between the tactical systems is illustrated in figure 1-2 (foldout at end of this chapter). The basic function and interface of the systems that comprise the POSEIDON FBM weapon system will be explored.


POSEIDON SSB(N)627 CLASS FBM WEAPON SYSTEM
TACTICAL SYSTEMS
MTRE MK-7
NON-TACTICAL SYSTEM
NAVIGATION SYSTEM MK-2 MOD-6
MISSILE TEST & READINESS EQUIPMENT MTRE MK-6
MISSILE LAUNCHING SYSTEM MK-24 MOD-0
SSB(N)627 CLASS SUBMARINE SHIP SYSTEM
POSEIDON FIRE CONTROL SYSTEM MK-88 MOD-1
POSEIDON MISSILE C3
IDAS

258.1

Figure 1-1.—Organization of FBM Weapon System.

SHIP SYSTEM

The ship system (fig. 1-3) provides supporting services to the other systems in the FBM weapon system. These supporting services include electrical, pneumatic, and hydraulic power.

The electrical power equipment generates, converts, rectifies, and distributes power required for control and operation of the FBM weapon system. Electrical power is supplied at 450 V, 60 Hz; 120 V, 400 Hz; and 250, 31.5, and 28 V d.c. The electrical power is routed to the FC systems, launching system, navigation system, missile, and MTRE.

The pneumatic power equipment supplies high-pressure nitrogen and air to the launching system to be used for FBM weapon system operation. Nitrogen pressurizes the tube during a submerged launch, purges the tube immediately after a surface launch, blows excess water from the tube during missile compensation, and inerts the tube atmosphere if abnormal temperatures are detected. Air is used during training exercises and to pressurize the tube in a tactical situation when the nitrogen supply has been exhausted.

The hydraulic power equipment supplies hydraulic pressure to operate control valves in the launching system. Hydraulic pressure operates the muzzle hatch (MH) and MH locking ring and locking pin mechanisms, the underhatch pressurization valve, the air or nitrogen isolation valves, and the compensating blow and sea valves.

NAVIGATION SYSTEM

The navigation system continuously generates and routes ship velocity, position, and attitude data to the FC system for use in the generation of missile guidance data. The primary source of navigation data is the ship inertial navigation system (SINS). Equipment (fig. 1-4) used in support of SINS includes multispeed repeaters (MSR), the central navigational computers (CNC), Loran receiving and radio navigation sets, and the navigation control console (NCC).

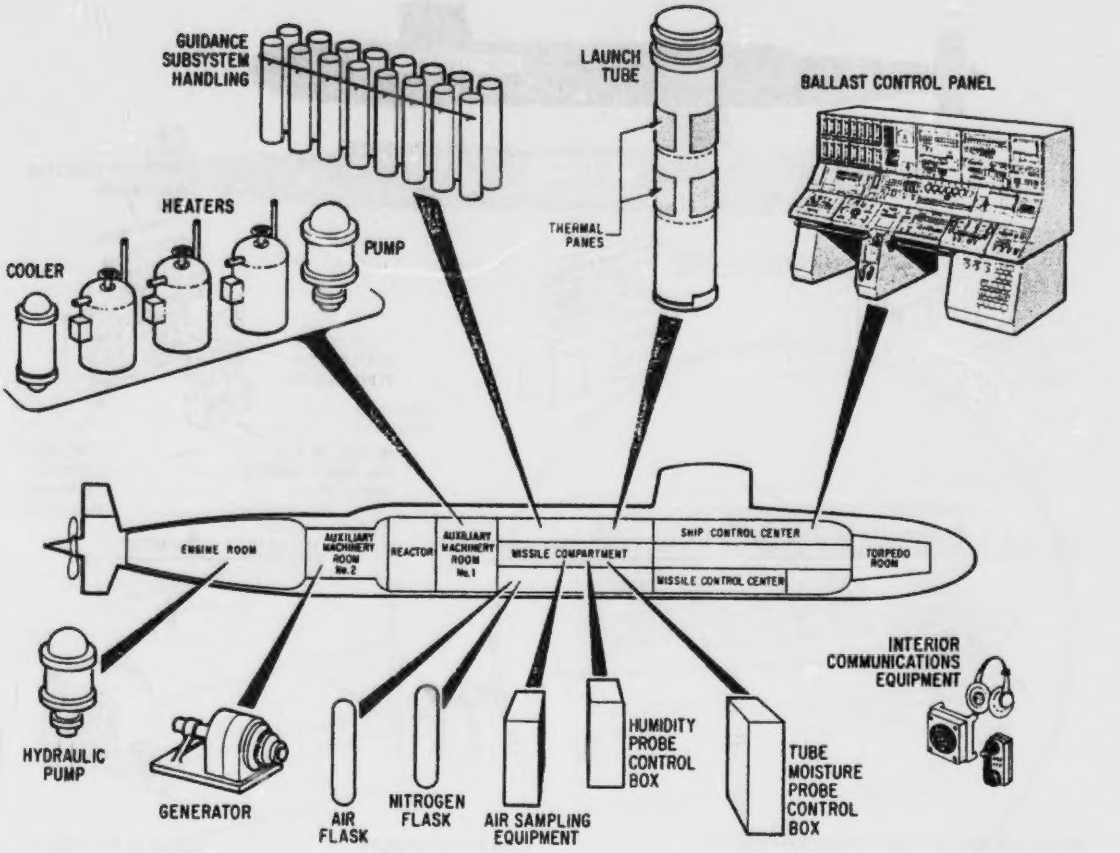
SINS generates and routes velocity data (fig. 1-2) to the missile motion subsystem (MMSS) and position data to the servo group subsystem (SGSS) in the FC system. Attitude data is routed to both the MMSS and SGSS via the MSR. The MSR routes the attitude data in different synchro speeds to provide for the various degrees of data accuracy required by the FC system. This data is used to update guidance data computations required by the continuous changing of the ship's attitude and position.

To maintain the navigation data within the accuracy requirements of the FBM weapon system, SINS is periodically reset to correct for any accumulated errors. To obtain these reset data, the CNC, on command from the NCC, compares data generated by SINS to data generated by known land-based stations or navigation satellites. The SINS data routed from SINS to the CNC includes velocity and position information. The fix-position data, routed from Loran or the radio navigation set, includes position information established from known points. The CNC compares this data and generates the SINS reset data that is routed to SINS to update the SINS computation. The CNC also generates printout and satellite tracking data for use by the navigation system. The printout data is routed to the NCC to be printed and displayed. The satellite tracking data is routed to the radio navigation set to aid in the fix-position operation.

The NCC displays the status of all navigation equipment and functions. In addition, the NCC controls the selection of the SINS and reset equipment and generates and routes commands to the CNC. Depending upon the type of commands generated, the CNC routes either printout data to the NCC or SINS reset data to the SINS. The NCC also routes a navigation status signal to the FC system.

POSEIDON FIRE CONTROL SYSTEM

The POSEIDON FC system (fig. 1-5) prepares the missiles for sequential launching and coordinates the operation of the FBM weapon system during the launch sequence. To prepare a missile for launch, FC performs four basic functions: supplies missile prelaunch power and monitoring of guidance system


GUIDANCE SUBSYSTEM HANDLING
LAUNCH TUBE
BALLAST CONTROL PANEL
THERMAL PANES
HEATERS
PUMP
COOLER
ENGINE ROOM
AUXILIARY MACHINERY ROOM No. 2
REACTOR
AUXILIARY MACHINERY ROOM No. 1
MISSILE COMPARTMENT
SHIP CONTROL CENTER
MISSILE CONTROL CENTER
TORPEDO ROOM
INTERIOR COMMUNICATIONS EQUIPMENT
HYDRAULIC PUMP
GENERATOR
AIR FLASK
NITROGEN FLASK
AIR SAMPLING EQUIPMENT
HUMIDITY PROBE CONTROL BOX
TUBE MOISTURE PROBE CONTROL BOX

258.3

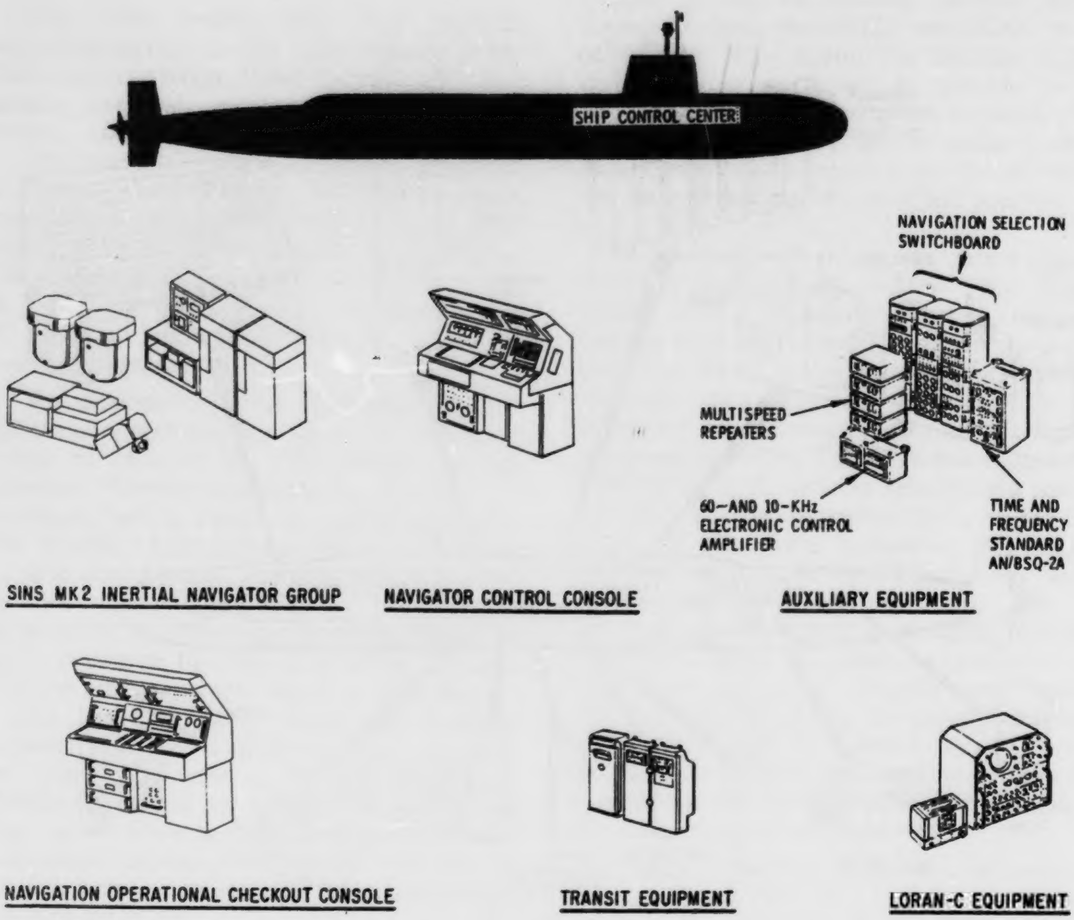
Figuer 1-3.—Ship System and Equipment Location.

temperature; orients the guidance system stable platform; provides guidance readin and fuze set data to the missile; coordinates the launch sequence (fig. 1-2).

Missile prelaunch power and guidance system temperature monitoring are provided by the temperature monitor power supply (TMPS). Prior to the missile being switched to internal power, TMPS routes prelaunch power to the missile electrical subsystem to enable missile circuit operation. TMPS also uses guidance monitoring signals to monitor guidance system temperature and ensures that the gimbal angle errors remain within an acceptable range.

Orientation of the guidance system stable platform is accomplished by the command slew subsystem (CSSS), alignment subsystem (ALNSS), and erection subsystem (ESS). This orientation establishes a reference for missile in-flight computations. Both the ALNSS and ESS use platform position signals from the missile guidance system to develop orientation signals. These signals are routed to the guidance system to control the orientation of the stable platform.

The guidance readin data is provided through the interaction of the digital control computer (DCC) group, SGSS, MMSS, and digital readin subsystem (DRISS). Fuze-set data


SHIP CONTROL CENTER
NAVIGATION SELECTION SWITCHBOARD
MULTISPEED REPEATERS
60-AND 10-KHz ELECTRONIC CONTROL AMPLIFIER
TIME AND FREQUENCY STANDARD AN/BSQ-2A
SINS MK2 INERTIAL NAVIGATOR GROUP
NAVIGATOR CONTROL CONSOLE
AUXILIARY EQUIPMENT
NAVIGATION OPERATIONAL CHECKOUT CONSOLE
TRANSIT EQUIPMENT
LORAN-C EQUIPMENT

258.4

Figure 1-4.—Navigation Equipment.

generation requires the FSSS group, and associated interface equipments. Because of the resultant effects of ever-changing ship position and attitude on the missile, the missile guidance data must be computed just prior to launch. Ship heading and position data, in analog form, are routed from the navigation system to the SGSS and then to the DCC group in digital form. The DCC group combines this data with precomputed guidance data stored in the DCC group memory and generates the guidance data that is routed to DRISS.

The missile motion data, representing the effects of the moving ship on the missile, is generated by the MMSS using the ship attitude and velocity data from the navigation system. The missile motion data is also routed to DRISS. At the proper time and in the proper sequence, DRISS routes guidance data and missile motion data to the missile guidance system as guidance readin data. Simultaneously, the DCC group is computing the fuze-set data using information stored in the DCC group memory. The fuze-set data is routed from the DCC to the FSSS, to the command sequencer in the missile electrical subsystem.

Coordination of the launch sequence is controlled by the control and display subsystem (CDSS). CDSS receives status signals from the navigation system, launcher status signals from

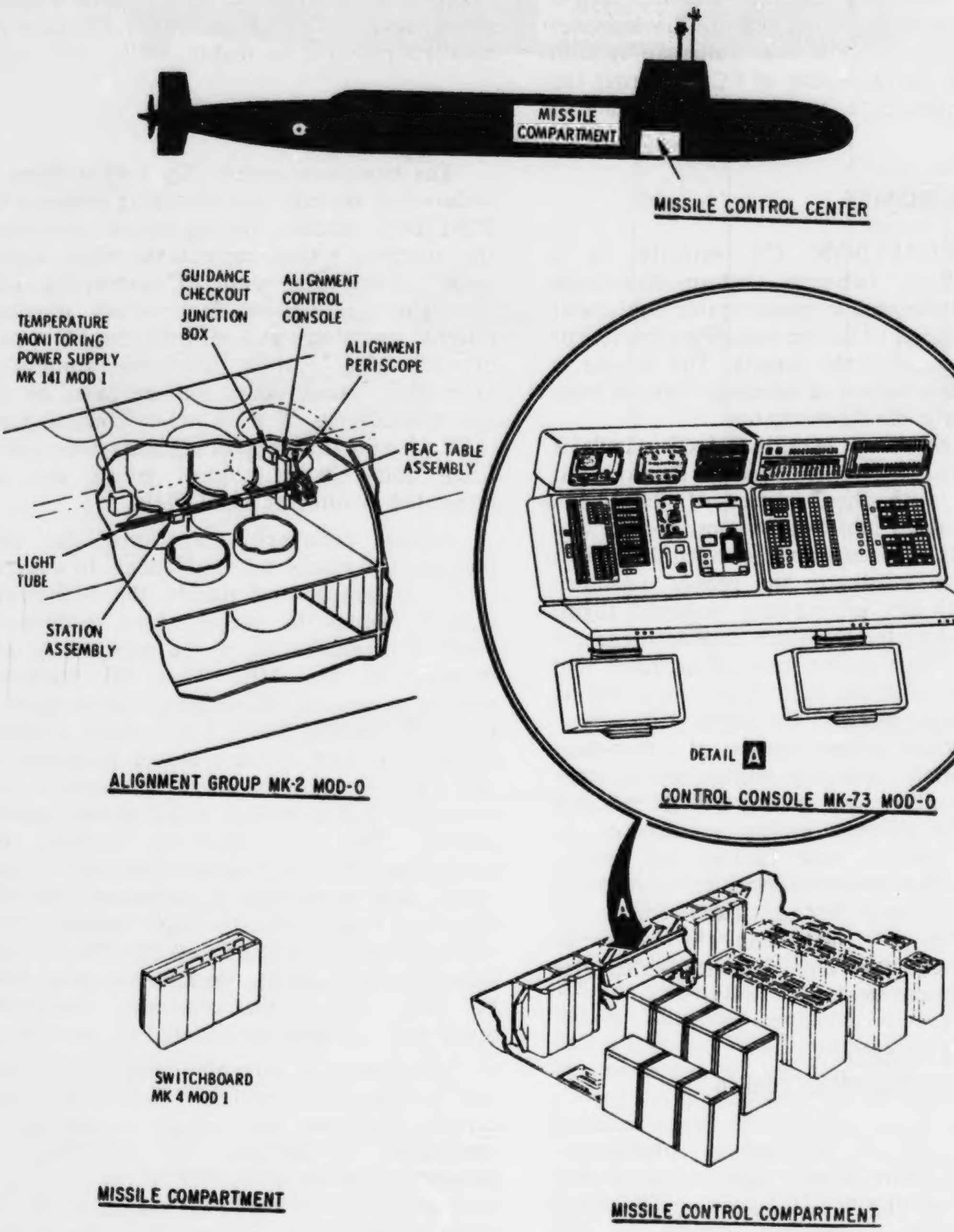

MISSILE COMPARTMENT
MISSILE CONTROL CENTER
GUIDANCE CHECKOUT JUNCTION BOX
ALIGNMENT CONTROL CONSOLE
TEMPERATURE MONITORING POWER SUPPLY MK 141 MOD 1
ALIGNMENT PERISCOPE
PEAC TABLE ASSEMBLY
LIGHT TUBE
STATION ASSEMBLY
ALIGNMENT GROUP MK-2 MOD-0
DETAIL A
CONTROL CONSOLE MK-73 MOD-0
A
SWITCHBOARD MK 4 MOD 1
MISSILE COMPARTMENT
MISSILE CONTROL COMPARTMENT

Figure 1-5.—Fire Control Subsystem.

258.5

the integrated monitoring panel (IMP) in the launching system, missile status signals from MTRE, and FC status signals from the remainder of FC. CDSS monitors these status signals to determine when to generate the appropriate control signals to be routed to, the launcher control panel (LCP) in the launching system, MTRE, and the remainder of FC, to permit the launch sequence to proceed in a sequential operation.

POSEIDON MISSILE

The POSEIDON C3 missile is a solid-propellant, two-stage, intermediate-range ballistic missile with a maneuverable equipment section designed to deliver reentry bodies (REB) to single or multiple targets. The missile is designed for a surface or submerged launch from a fleet ballistic missile submarine.

The flight of a POSEIDON C3 missile is divided into two phases, boost and deployment. Coincident with these phases of flight, the missile is divided into two systems, booster and delivery. The booster provides controlled thrust to place the missile in the proper trajectory during first- and second-stage powered flight. The delivery system provides the control forces needed to obtain the precise attitude and velocity for multiple REB deployment during the deployment phase of the flight.

The booster system consists of a first-stage motor assembly, interstage section, second-stage motor assembly, and forward skirt adapter section. The delivery system consists of an equipment section, nose fairing, and reentry subsystem. The reentry subsystem is enclosed within the nose fairing. Each missile is approximately 34 feet long, 74 inches in diameter at the base, and 72 inches in diameter at the equipment section.

MISSILE TEST AND READINESS EQUIPMENT MK 6

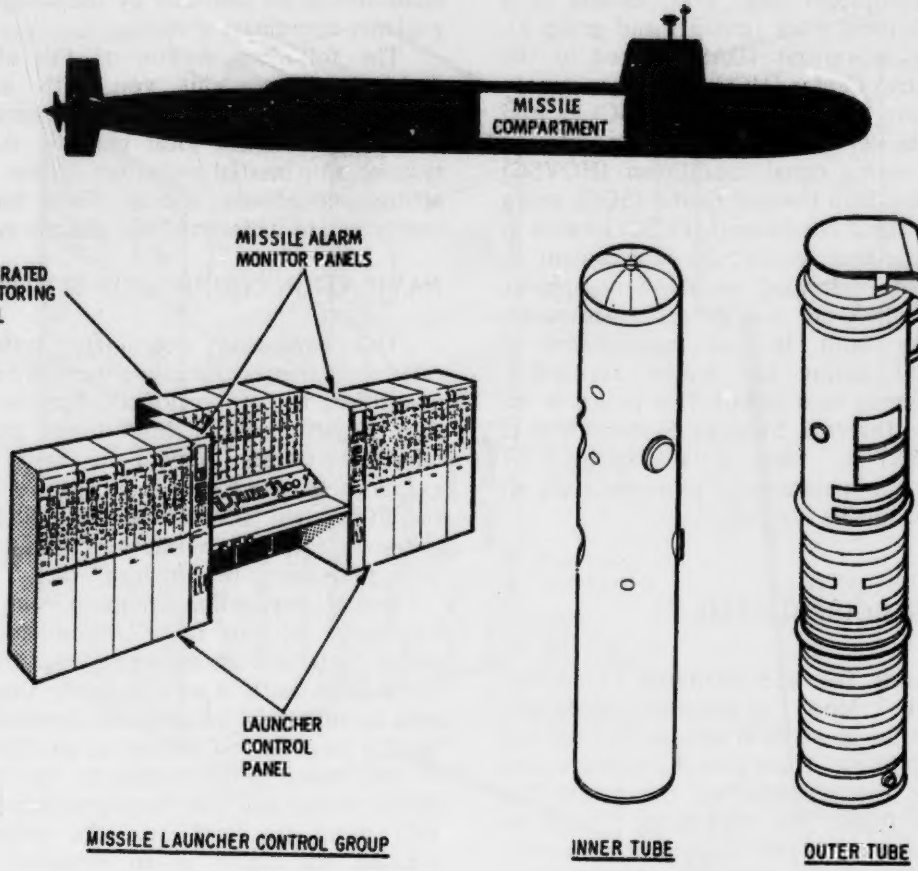
MTRE Mk 6 performs a preparation sequence on each missile prior to launch (fig. 1-2). Under control of CDSS in FC, MTRE Mk 6 routes missile preparation signals to the electrical and flight control subsystems. Preparation status signals are routed back to MTRE Mk 6 by the missile electrical and flight control subsystems in response to the status of missile launch readiness. When all preparation functions are completed, MTRE routes a missile status signal to CDSS to inform FC that the missile is prepared for flight.

LAUNCHING SYSTEM

The launching system (fig. 1-6) provides an underwater stowage and launching platform for POSEIDON missiles. During launch operations, the launching system controls the missile launch under the direction of the FC system (fig. 1-2). The launching system continuously monitors internal operations and informs the FC system of launching system readiness conditions. Launching system operations are based on the coordinated use of a launcher control panel (LCP), missile tube, exploding bridgewire (EBW) firing unit, ejector control group, and the integrated monitoring panel (IMP).

During prelaunch operations, the LCP prepares the missile tube for launch. In response to FC system control signals, the LCP routes control signals to missile tube equipment, enabling pressurization of the missile tube and opening of the MH. When all prelaunch conditions are met, FC routes a control signal to the LCP, causing the LCP to initiate a missile launch. The LCP routes a launch command to the EBW firing unit which generates a fire command that is routed to the ejector control group. The fire command initiates the generation of a high-pressure mixture of gas, steam, and water that is introduced into the missile tube beneath the missile. This high-pressure mixture ejects the missile smoothly from the missile tube and away from the ship. All of the previously mentioned operations are operator initiated and controlled.

Throughout all launching system operations, the LCP and IMP monitor selected launching system functions and missile environmental conditions. In addition, the LCP routes a launcher status signal via IMP to the FC system that indicates the readiness condition of the launching system equipment, and a signal that indicates the selected launch mode (surface or



MISSILE LAUNCHER CONTROL GROUP

INNER TUBE

OUTER TUBE

258.6

Figure 1-6.—Launcher Subsystem.

submerged). IMP monitors for launcher alarms and missile alarms and displays the status of the missile environmental conditions. The LCP provides a visual display of EBW status, missile tube equipment status and ejector control group status.

INTEGRATED DATA ACQUISITION SUBSYSTEM M35

Integrated Data Acquisition Subsystem (IDAS) M35 automatically gathers pertinent data related to the operation of the weapon system equipment and personnel aboard operationally deployed submarines. IDAS accomplishes this by monitoring and recording the performance of critical functions during weapon system readiness tests (WSRT) and operational tests and follow-on tests (OT/FOT). WSRT operations are a series of simulated missile launches conducted during a tactical patrol exercise. WSRT operations are monitored by permanently installed IDAS equipment aboard the submarine. OT/FOT operations are a series of actual POSEIDON missile tests flights conducted by the submarine at an instrumented missile test range. OT/FOT operations are monitored by permanently installed equipment with additional equipment furnished by an FBM tender or shore facility.

IDAS equipment (fig. 1-7) consists of a double equipment stack (group 1 and group 2), referred to as central IDAS, located in the Missile Control Center (MCC), and three remote units: a heave signal conditioner (HSC) located in the middle level of the Missile Compartment (MC), a hovering signal conditioner (HOVSC) located in the Ship Control Center (SCC), and a fire control signal conditioner (FCSC) located in MCC. Maintenance, except the replacement of tapes, is not performed on IDAS equipment during patrol, even though self-maintenance features are built in. All maintenance is accomplished during the tender availability period following each patrol. This policy is set forth by the Director, Strategic Systems Project Office (SSPO), who is responsible for establishing the maintenance procedures for all fleet ballistic missile systems.

MISSILE TEST AND READINESS EQUIPMENT MK 7

The Missile Test and Readiness Equipment (MTRE) Mk 7 Mod 2 is installed aboard the FBM submarine to perform periodic tests on the POSEIDON missile. These periodic tests are used to evaluate the readiness of the missile for launch and flight. The MTRE Mk 7 may be paralleled with the MTRE Mk 6 during a tactical launch. In this configuration, the MTRE Mk 7 simply provides measurements and readout services, while the MTRE Mk 6 actually performs the missile prepare functions.

WEAPON SYSTEM FRAMES OF REFERENCE

The weapon system establishes several frames of reference to define the relationship between inertial space and Earth. In marine inertial navigation it is necessary to relate the motions sensed by the ship inertial navigation system (SINS) to the Earth's surface. In inertial missile guidance, it is necessary to relate the motions sensed by SINS to each missile, to align and erect each missile stable platform, and to relate the motions sensed by the guidance system to a fixed point in space. These relationships are provided by the navigation and guidance coordinate systems.

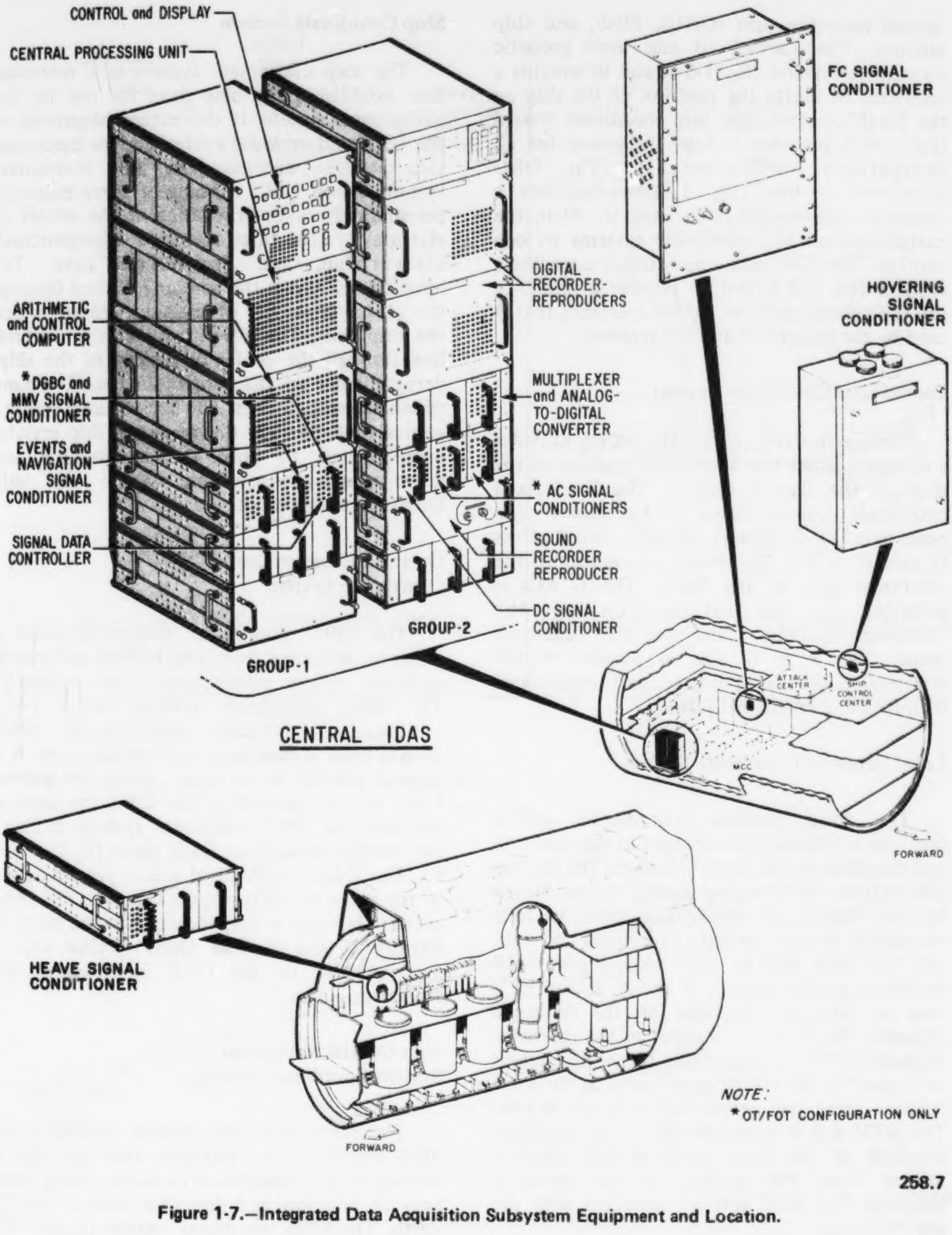
The following section of this chapter is designed to acquaint you with navigation coordinate systems, including Earth's-fixed coordinate systems, local geodetic coordinate systems, ship inertial navigation system, and ship attitude coordinate system. These basics will enable you to understand the weapon system.

NAVIGATION COORDINATE SYSTEMS

The navigation coordinate systems are referenced frames that relate inertially measured quantities to proportionate Earth-referenced ship velocity, position, and attitude data. These reference frames provide a basis for the exchange of data from the navigation system to the FC system. In the navigation system, it is necessary to relate the motions sensed by SINS to motions across the Earth's surface.

Precise navigation requires an accurate knowledge of the Earth's shape and gravity vector variations at different locations on the Earth. The Earth is an elliptically shaped mass with an equatorial bulge caused by rotation. The Earth's shape is best defined as an ellipsoid that is everywhere perpendicular to the true local gravity vector and that corresponds most nearly with mean sea level over the entire Earth. Because the Earth is an irregularly shaped ellipsoid, an international reference ellipsoid is used for navigational purposes. The international reference ellipsoid is a mathematically regular surface derived by taking the mean value of the magnitude and direction of true local gravity vectors at different positions on the Earth. This process produces a reference ellipsoid (REV) that deviates from the true local vertical for different positions of the Earth. Positions plotted on the reference ellipsoid are referenced to Earth-fixed and local geodetic coordinate systems. As the ship changes position or as the Earth rotates, the REV axis of the ship's navigation system must be continually torqued to maintain the axis at local vertical. The precise motion and position of a ship on the Earth's surface are described in terms of an applicable coordinate system.

The navigation system uses six coordinate systems: Earth-fixed, local geodetic, ship,


CONTROL and DISPLAY
CENTRAL PROCESSING UNIT
ARITHMETIC and CONTROL COMPUTER
*DGBC and MMV SIGNAL CONDITIONER
EVENTS and NAVIGATION SIGNAL CONDITIONER
SIGNAL DATA CONTROLLER
GROUP-1
GROUP-2
DIGITAL RECORDER-REPRODUCERS
MULTIPLEXER and ANALOG-TO-DIGITAL CONVERTER
* AC SIGNAL CONDITIONERS
SOUND RECORDER REPRODUCER
DC SIGNAL CONDITIONER
CENTRAL IDAS
FC SIGNAL CONDITIONER
HOVERING SIGNAL CONDITIONER
ATTACK CENTER
SHIP CONTROL CENTER
MCC
FORWARD
HEAVE SIGNAL CONDITIONER
FORWARD

NOTE:
* OT/FOT CONFIGURATION ONLY

258.7

Figure 1-7.—Integrated Data Acquisition Subsystem Equipment and Location.

optical reference unit (ORU), SINS, and ship attitude. The Earth-fixed and local geodetic coordinate systems (fig. 1-8 A and B) provide a reference to locate the position of the ship on the Earth's surface. The ship coordinate system (fig. 1-8C) provides a basic reference for all navigational measurements. The ORU coordinate system (fig. 1-8D) establishes a common reference that is used to relate the navigation and FC coordinate systems to one another. The SINS and ship attitude coordinate systems (fig. 1-8 E and F) provide a reference for the measurement of ship movements that is used by the navigation and FC systems.

Earth-Fixed Coordinate System

The Earth-fixed coordinate system provides a reference frame that locates the position of the ship on the Earth's surface. The Earth-fixed coordinate system, figure 1-8A, consists of a polar axis (P), Greenwich axis (G), and P across G axis (P x G). The P axis is parallel to the rotational axis of the Earth. The G axis is parallel to the intersection of the Greenwich-meridian plane and the equatorial plane. The P x G axis is parallel to the intersection of the 90-degree, east-longitudinal meridian, and equatorial planes.

Local Geodetic Coordinate System

The local geodetic coordinate system provides a reference for changes in ship position and direction on the Earth's surface. This system also defines the changing gravity vector caused by the Earth's curvature. The local geodetic coordinate system consists of a north (N) axis, east (E) axis, and an REV axis. Figure 1-8B illustrates the orientation of the N, E, and REV axes at different locations on the reference ellipsoid. The N axis is tangent to the reference ellipsoid in the local meridian plane. The E axis is tangent to the reference ellipsoid in the local latitude plane and perpendicular to the N axis. The REV axis is perpendicular to the reference ellipsoid at the local position and directed inward from the surface of the reference ellipsoid. The REV axis is coincident with the gravity vector.

Ship Coordinate System

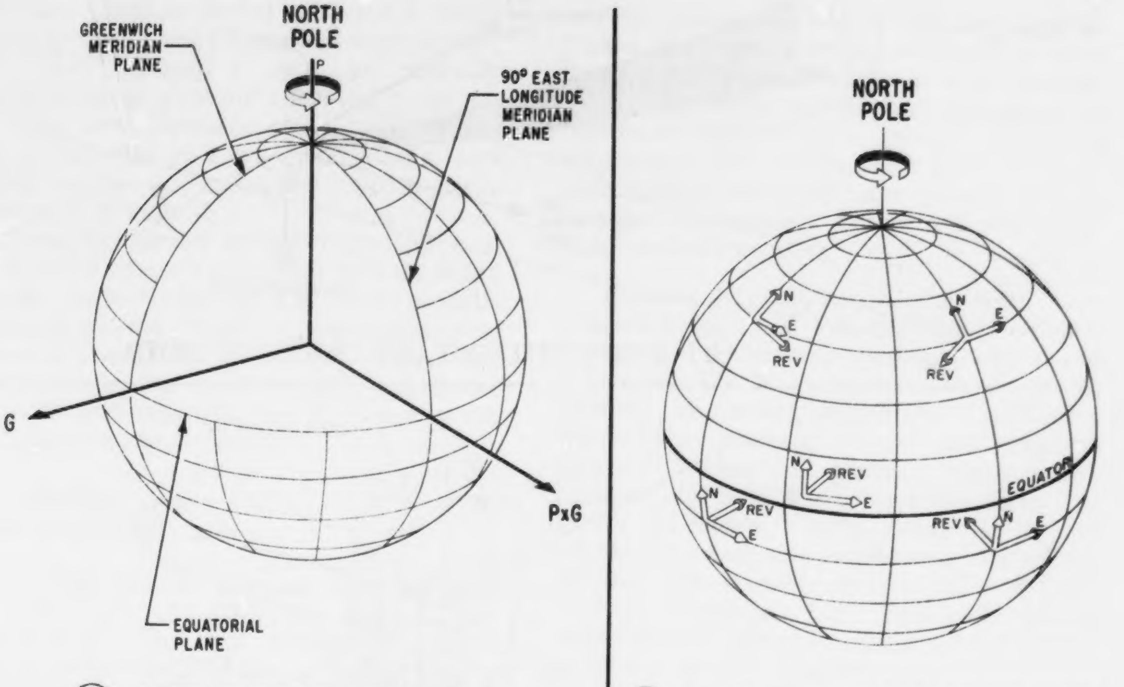
The ship coordinate system is a reference that establishes the ship axes for use by the navigational system. It also enables alignment of the ORU and provides a reference for measuring ship attitude changes. The ship coordinate system, figure 1-8C, consists of three mutually perpendicular axes originating at the center of ship gravity. The three axes are the longitudinal, athwartship, and deck-to-keel axes. The longitudinal axis is the fore and aft line through the center of gravity of the ship, around which the ship rolls. The athwartship axis is a lateral line through the center of gravity of the ship, perpendicular to the longitudinal axis, around which the ship pitches. The deck-to-keel axis is a vertical line through the center of ship gravity, perpendicular to both the longitudinal and athwartship axes, around which the ship longitudinal axis pivots (yaw).

Optical Reference Unit Coordinate System

The ORU coordinate system provides a common reference from which SINS and missile guidance system misalignments are measured. The ORU coordinate system, figure 1-8D, consists of mutually perpendicular ORU longitudinal, athwartship, and vertical axes. It is aligned parallel to the ship coordinate system. Four mirrors located in the ORU are used to establish the ORU coordinate system. Each of the mirrors defines an ORU plane (C, D, E, or F). The ORU longitudinal axis is perpendicular to the plane of ORU mirrors C and E. The ORU athwartship axis is perpendicular to the plane of mirrors D and F. The ORU vertical axis is perpendicular to the ORU longitudinal and athwartship axes.

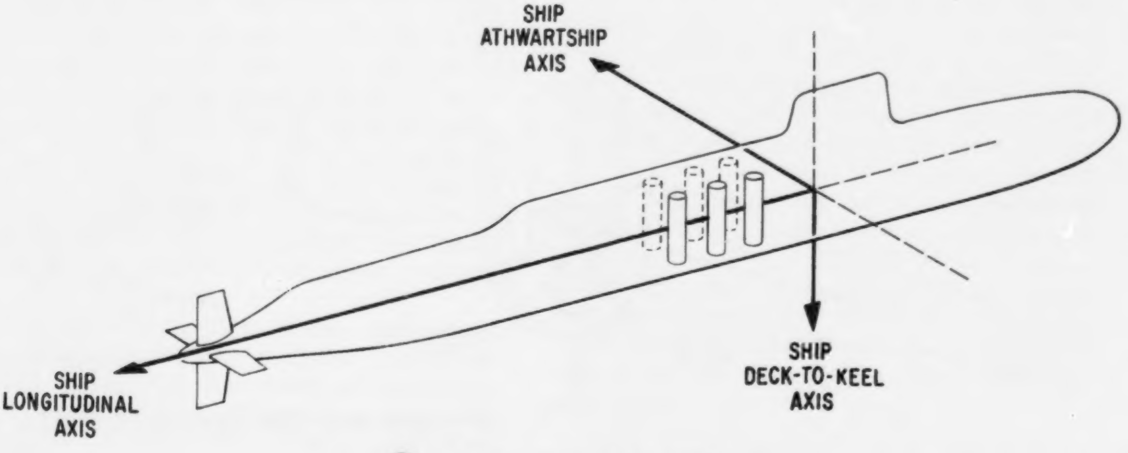
Ship Inertial Navigation System Coordinate System

The SINS coordinate system establishes the SINS inertial stable platform axes and aids in relating ship accelerations measured along these axes to position and direction changes on the Earth. The SINS coordinate system, figure 1-8E,


GREENWICH MERIDIAN PLANE
NORTH POLE
P
90° EAST LONGITUDE MERIDIAN PLANE
G
PxG
EQUATORIAL PLANE
NORTH POLE
N
E
REV
N
E
REV
N
REV
E
N
REV
E
EQUATOR
REV
N
E

Ⓐ - EARTH-FIXED COORDINATE SYSTEM

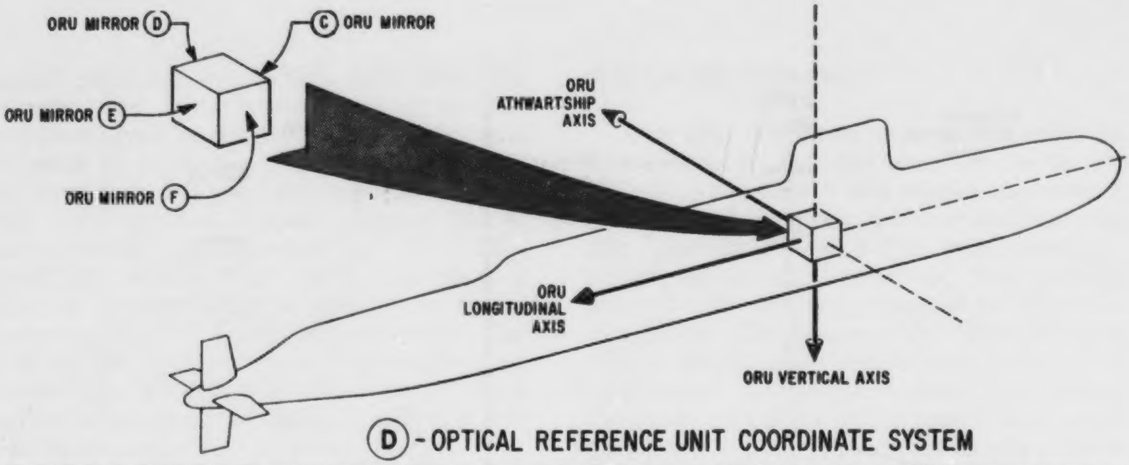
Ⓑ - LOCAL GEODETIC COORDINATE SYSTEM


SHIP ATHWARTSHIP AXIS
SHIP LONGITUDINAL AXIS
SHIP DECK-TO-KEEL AXIS

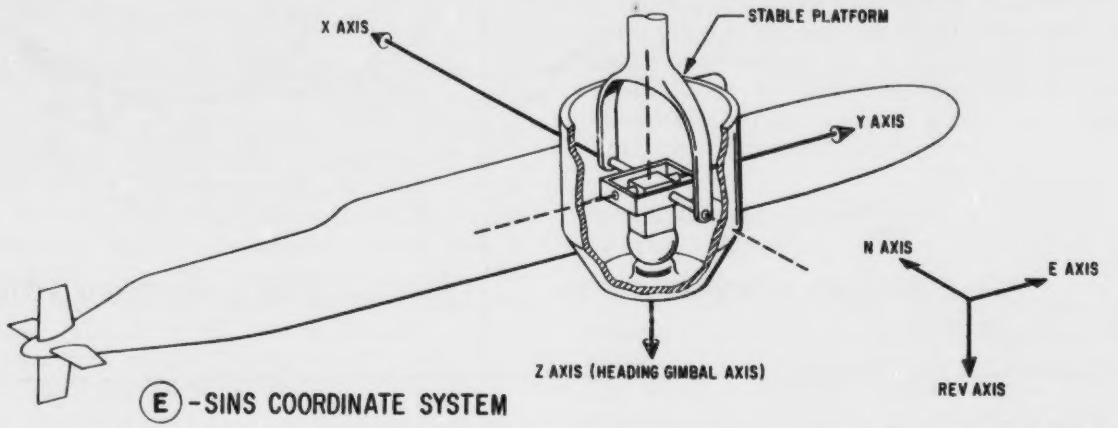
Ⓒ - SHIP COORDINATE SYSTEM

258.8

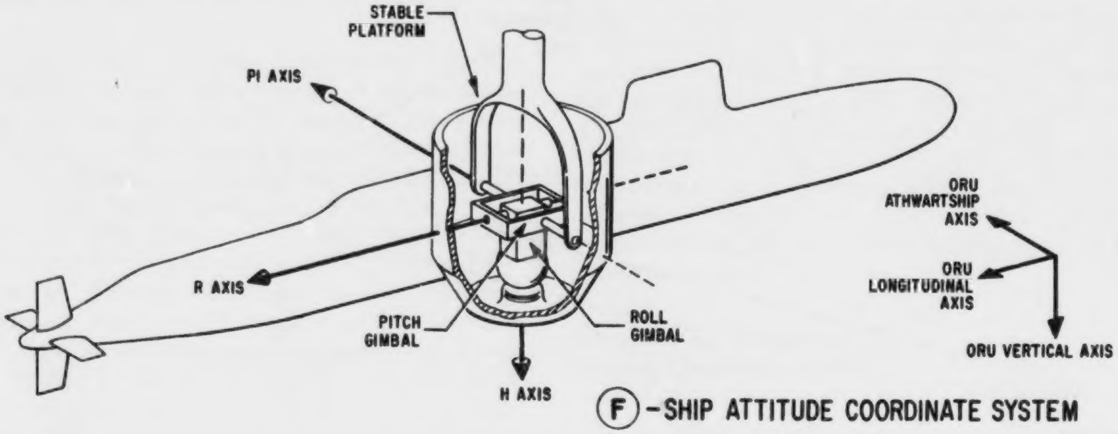
Figure 1-8.—Navigation Coordinate Systems.


ORU MIRROR (D)
(C) ORU MIRROR
ORU MIRROR (E)
ORU MIRROR (F)
ORU ATHWARTSHIP AXIS
ORU LONGITUDINAL AXIS
ORU VERTICAL AXIS

(D) - OPTICAL REFERENCE UNIT COORDINATE SYSTEM


X AXIS
STABLE PLATFORM
Y AXIS
N AXIS
E AXIS
Z AXIS (HEADING GIMBAL AXIS)
REV AXIS

(E) - SINS COORDINATE SYSTEM


STABLE PLATFORM
PI AXIS
R AXIS
PITCH GIMBAL
ROLL GIMBAL
H AXIS
ORU ATHWARTSHIP AXIS
ORU LONGITUDINAL AXIS
ORU VERTICAL AXIS

(F) - SHIP ATTITUDE COORDINATE SYSTEM

258.8

Figure 1-8.—Navigation Coordinate Systems—Continued.

consists of mutually perpendicular X, Z, and Y axes. The Z axis is the SINS stable platform train axes (heading gimbal axis) and is ideally aligned and maintained coincident with the REV axis. The X and Y axes are mutually perpendicular to each other and the Z axis and lie in the local horizontal plane. The X and Y axes are directed in a known orientation with respect to true north (usually pointing north, south, east, or west).

During the normal navigation configuration, the X and Y axes are coincident with the N and E axes, respectively, of the local geodetic coordinate system. Therefore, ship accelerations measured along the X, Y, and Z axes are referenced to the local geodetic coordinate system to determine the rate of change of the ship's position and direction.

Ship Attitude Coordinate System

The ship attitude coordinate system defines the axes used by SINS for ship attitude measurements. The ship attitude coordinate system, figure 1-8F, consists of roll (R), pitch (PI), and heading (H) axes. The R axis coincides with the intersection of the local horizontal plane and the deck-normal plane that contains the ORU longitudinal axis. The deck-normal plane is perpendicular to the deck plane of the ship and parallel to the ship coordinate system's ship deck-to-keel axis. The R axis is always located in the local horizontal plane and is the middle (roll) gimbal axis. The PI axis is coincident with and in the same direction as the ORU athwartship axis. The PI axis is the outer (pitch) gimbal axis and moves out of the local horizontal plane when the ship rolls. The H axis is coincident with and in the same direction as the REV axis of the local geodetic coordinate system. The H axis is also the stable platform axis.

The following section of the chapter will acquaint you with the guidance coordinate systems, including the platform coordinate system, computing coordinate system, gimbal coordinate system, and missile coordinate system. A basic knowledge of these systems will assist you in understanding the POSEIDON missile and associated Mk 3 guidance.

GUIDANCE COORDINATE SYSTEMS

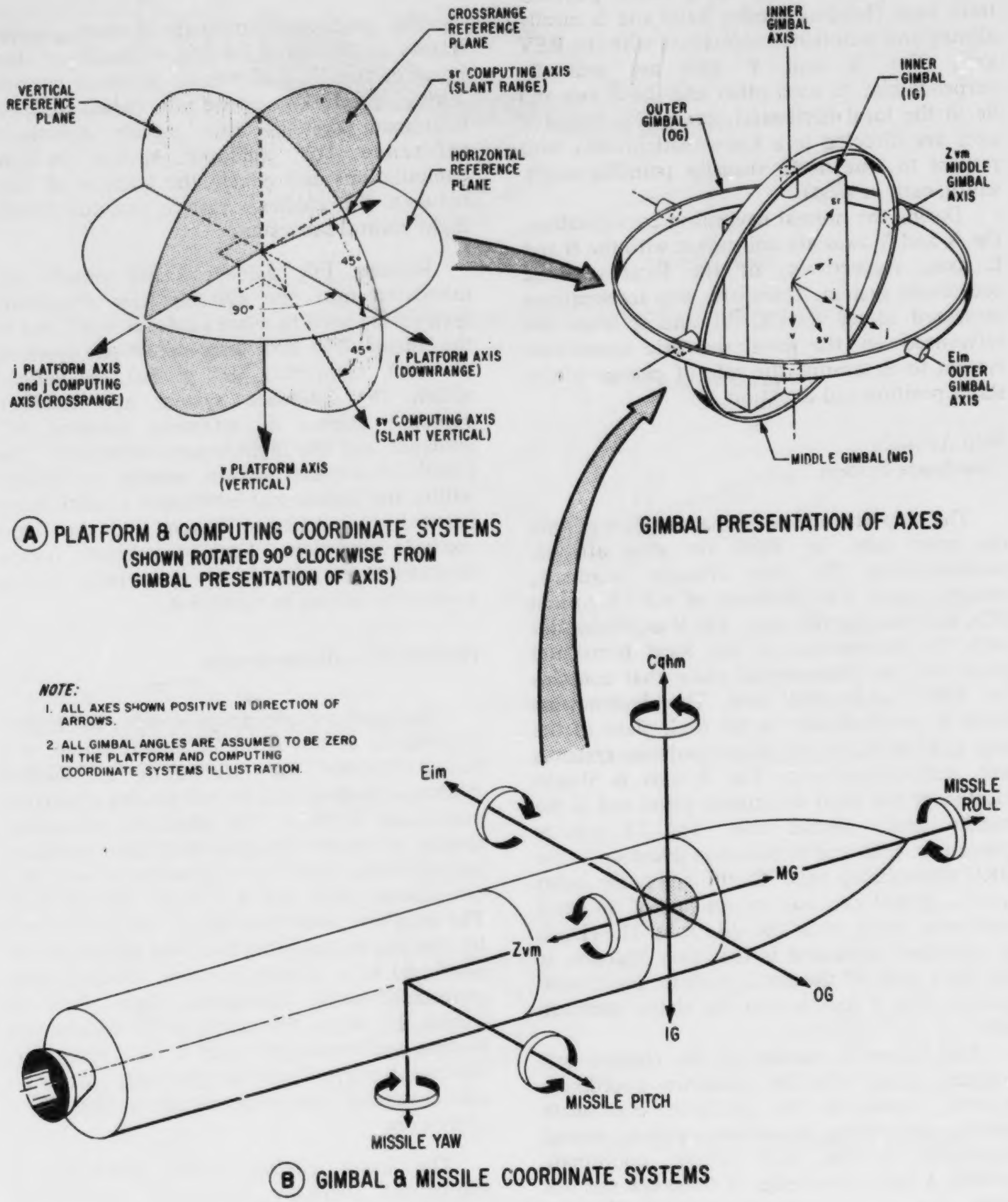
The guidance coordinate systems provide frames of reference for the exchange of data between the FC and missile guidance systems during prelaunch operations. The guidance coordinate systems also provide directional reference for guidance system in-flight computations and enable the transfer of data between the guidance system and the missile flight control subsystem.

Because FC, guidance, and missile are integrated into one system, four coordinate systems are used to relate guidance to FC and to the missile. The first three coordinate systems, platform, computing, and gimbal, are defined within the guidance system and establish common frames of reference between FC, guidance and the flight control subsystem. The fourth coordinate system, missile, is defined within the missile and establishes a relationship between the guidance system and the flight control subsystem. Each coordinate system contains three axes, which are related to one another as defined in figure 1-9.

Platform Coordinate System

The platform coordinate system, sometimes referred to as the firing or launch frame, is a basic reference for establishing an inertial guidance platform and for referencing associated coordinate systems. The platform coordinate system of figure 1-9A consists of three mutually perpendicular axes: an r (downrange) axis, a j (crossrange) axis, and a v (local vertical) axis. The axes are predefined by FC prior to launch by erecting and aligning the inner gimbal (stable platform) to a definite position, which is then maintained stable throughout flight. Prior to launch, FC aligns the r axis to the true launch bearing and erects the v axis to local vertical at the launch point. These two processes place the j axis crossrange and perpendicular to both the r and v axes.

The inner gimbal (stable platform) is maintained inertially referenced throughout flight; that is, the v axis remains parallel to local vertical at the point of launch, and the r axis


CROSSRANGE REFERENCE PLANE
sr COMPUTING AXIS (SLANT RANGE)
VERTICAL REFERENCE PLANE
HORIZONTAL REFERENCE PLANE
45°
90°
45°
j PLATFORM AXIS and j COMPUTING AXIS (CROSSRANGE)
r PLATFORM AXIS (DOWNRANGE)
sv COMPUTING AXIS (SLANT VERTICAL)
v PLATFORM AXIS (VERTICAL)
INNER GIMBAL AXIS
INNER GIMBAL (IG)
OUTER GIMBAL (OG)
Zvm MIDDLE GIMBAL AXIS
sr
r
j
v
sv
Eim OUTER GIMBAL AXIS
MIDDLE GIMBAL (MG)
Cqhm
Eim
MISSILE ROLL
MG
Zvm
OG
IG
MISSILE PITCH
MISSILE YAW

Ⓐ PLATFORM & COMPUTING COORDINATE SYSTEMS (SHOWN ROTATED 90° CLOCKWISE FROM GIMBAL PRESENTATION OF AXIS)

GIMBAL PRESENTATION OF AXES

NOTE:
1. ALL AXES SHOWN POSITIVE IN DIRECTION OF ARROWS.
2. ALL GIMBAL ANGLES ARE ASSUMED TO BE ZERO IN THE PLATFORM AND COMPUTING COORDINATE SYSTEMS ILLUSTRATION.

Ⓑ GIMBAL & MISSILE COORDINATE SYSTEMS

258.9

Figure 1-9.—Guidance Coordinate Systems.

remains aligned to the true launch bearing. During flight, the platform coordinate system is directly related to the gimbal coordinate system and, therefore, is used during the transformation of steering commands from guidance to the missile frame.

Computing Coordinate System

The computing coordinate system is established by the orientation of the input axes of the inertial acceleration measurement devices mounted on the stable platform. The computing coordinate system, figure 1-9A, consists of three inertial reference computing axes: an sr (slant range) axis, an sv (slant vertical) axis, and a j (crossrange) axis. These axes are fixed with respect to the inner gimbal (stable platform) only. During prelaunch, FC uses the computing coordinate system to establish orientation of the stable platform, which is the inner gimbal assembly.

The required orientation is accomplished through the erection and alignment process that utilizes the gyro and accelerometer devices located on the stable platform. The inner gimbal is positioned so that the sr axis is 45 degrees above the horizontal and is contained in the plane defined by the platform coordinate system r and v axes. The sv axis is then 45 degrees below the horizontal and is contained in the same plane as the sr axis. The j axis is coincident with the platform coordinate system j axis and perpendicular to the sr and sv axes. During prelaunch, FC uses the computing axes to compute some of the guidance quantities that are read into the computer. During flight, the computing axes define the directions in which computations are made to calculate corrections to the missile attitude and to sense the specific values of velocity that are prerequisites to initiate certain events.

Gimbal Coordinate System

The gimbal coordinate system, sometimes referred to as the guidance frame, provides a reference for stabilization of the platform. The gimbal coordinate system, figure 1-9B, is defined by the axes of the three guidance assembly gimbals: Cqhm (inner gimbal axis), Zvm (middle gimbal axis), and Eim, (outer gimbal axis). When the stable platform is erected, the v axis, inner gimbal axis, and the local vertical are all in parallel. The gimbal axes in the gimbal coordinate system differ from the axes in the other coordinate systems in that all three axes are not always mutually perpendicular.

Cqhm and Eim are always perpendicular to Zvm, but not necessarily perpendicular to each other. The only time Cqhm and Eim are perpendicular is when the outer gimbal axis and the middle gimbal axis are in the horizontal plane and the inner gimbal axis is in the vertical plane at launch. During flight, the outer gimbal will rotate about the middle gimbal axis when the missile rolls, because the outer gimbal is connected directly to the missile frame. The guidance system keeps the inner gimbal orientated to the launch local vertical to establish the inertial reference.

Missile Coordinate System

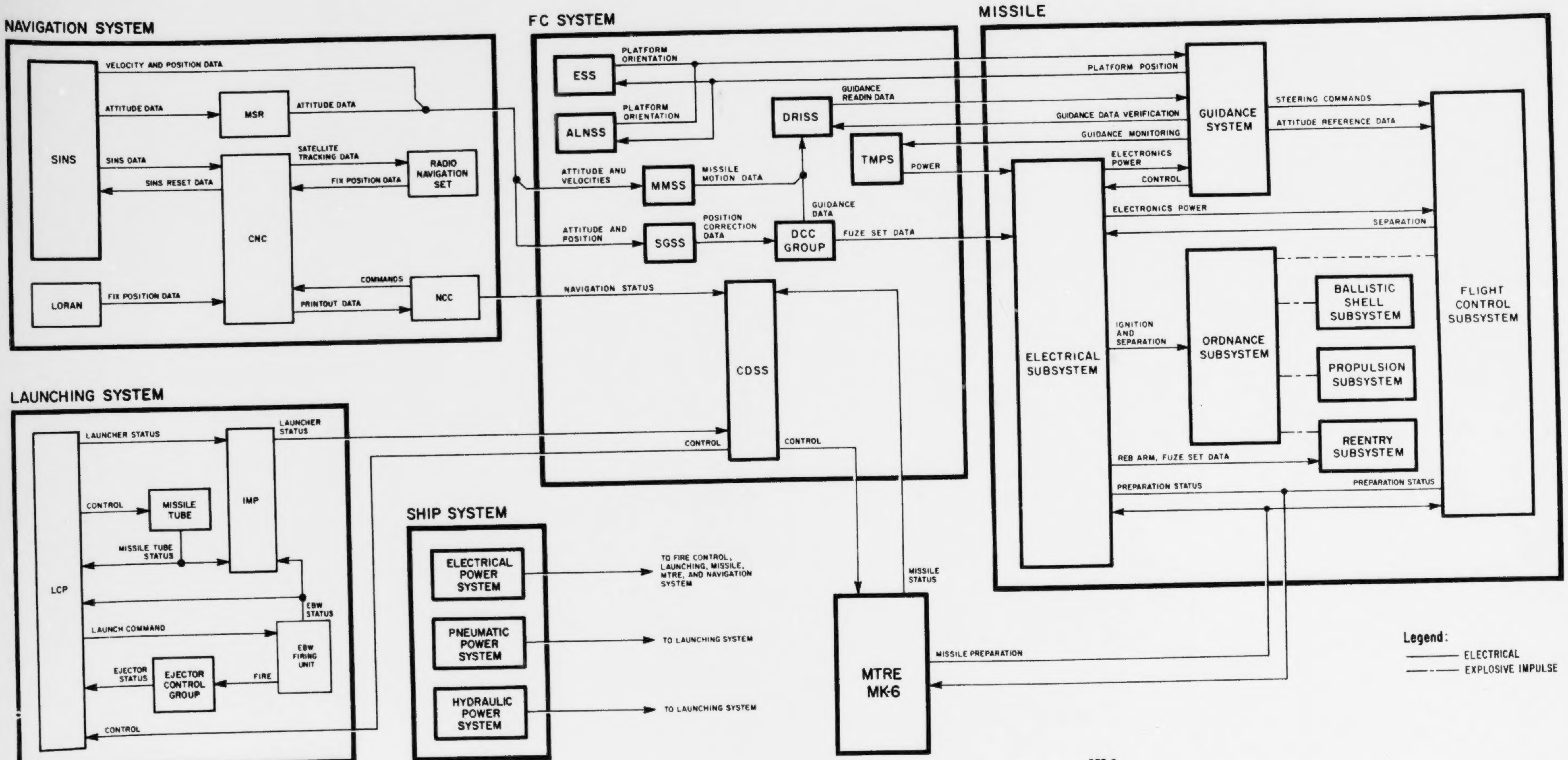
The missile coordinate system, sometimes referred to as the missile frame, provides a reference for measuring in-flight missile attitude changes with respect to the gimbal coordinate system. This permits the gimbal coordinate system to convert flight control steering commands from the platform coordinate system to the missile coordinate system. The missile coordinate system, figure 1-9B, consists of the three missile axes defined by missile thrust vector control equipment; they are the missile roll, pitch, and yaw axes.

The missile roll axis is coincident with the longitudinal axis of the missile, and the missile pitch and yaw axes are mutually perpendicular. Each axis is perpendicular to the missile roll axis. For a vertical missile, the pitch angle is coincident with the OG angle, but for a horizontal missile, the pitch angle differs from the OG angle by 90°. The axes of the missile coordinate system are defined by the directions in which the attitude of the missile is forced to move by the flight control subsystem during the missile flight.

Function of the Frames of Reference

The navigation and guidance coordinate systems provide the foundation upon which is built the remainder of the fire control problem. The navigation coordinate systems provide reference frames for determining the relative positions of the missile launch point and the target. The Mk 88 fire control system uses the navigation coordinate systems to calculate the guidance quantities that are read into the guidance computer prior to launch. The guidance data is referenced to the guidance coordinate system before being read into the guidance computer by the fire control system.

The required orientation of the guidance platform before launch is calculated using the navigation coordinate systems. The positioning of the guidance platform to the required orientation is performed using signals that are referenced to the guidance coordinate systems. The missile is steered along its flight path by commands generated by the guidance system. The guidance system calculates the required commands by sensing velocities referenced to the guidance computing coordinate system. The flight control subsystem of the missile responds to the steering commands by generating signals that move the missile about the missile coordinate system axes.


NAVIGATION SYSTEM
SINS
VELOCITY AND POSITION DATA
ATTITUDE DATA
MSR
ATTITUDE DATA
SINS DATA
SINS RESET DATA
CNC
SATELLITE TRACKING DATA
FIX POSITION DATA
RADIO NAVIGATION SET
LORAN
FIX POSITION DATA
COMMANDS
PRINTOUT DATA
NCC
FC SYSTEM
ESS
PLATFORM ORIENTATION
ALNSS
PLATFORM ORIENTATION
DRISS
GUIDANCE READIN DATA
TMPS
POWER
ATTITUDE AND VELOCITIES
MMSS
MISSILE MOTION DATA
GUIDANCE DATA
ATTITUDE AND POSITION
SGSS
POSITION CORRECTION DATA
DCC GROUP
FUZE SET DATA
NAVIGATION STATUS
CDSS
CONTROL
CONTROL
MISSILE
PLATFORM POSITION
GUIDANCE DATA VERIFICATION
GUIDANCE MONITORING
GUIDANCE SYSTEM
STEERING COMMANDS
ATTITUDE REFERENCE DATA
ELECTRONICS POWER
CONTROL
ELECTRONICS POWER
SEPARATION
ELECTRICAL SUBSYSTEM
IGNITION AND SEPARATION
ORDNANCE SUBSYSTEM
BALLISTIC SHELL SUBSYSTEM
PROPULSION SUBSYSTEM
REENTRY SUBSYSTEM
FLIGHT CONTROL SUBSYSTEM
REB ARM, FUZE SET DATA
PREPARATION STATUS
PREPARATION STATUS
LAUNCHING SYSTEM
LCP
LAUNCHER STATUS
IMP
LAUNCHER STATUS
CONTROL
MISSILE TUBE
MISSILE TUBE STATUS
EBW STATUS
LAUNCH COMMAND
EBW FIRING UNIT
EJECTOR STATUS
EJECTOR CONTROL GROUP
FIRE
CONTROL
SHIP SYSTEM
ELECTRICAL POWER SYSTEM
TO FIRE CONTROL, LAUNCHING, MISSILE, MTRE, AND NAVIGATION SYSTEM
PNEUMATIC POWER SYSTEM
TO LAUNCHING SYSTEM
HYDRAULIC POWER SYSTEM
TO LAUNCHING SYSTEM
MISSILE STATUS
MTRE MK-6
MISSILE PREPARATION
Legend:
ELECTRICAL
EXPLOSIVE IMPULSE

258.2

Figure 1-2.—Weapon System Interface.

CHAPTER 2

INERTIAL DEVICES AND MK 3 GUIDANCE

This chapter provides you with introductory information on inertial guidance systems and the devices that make them work.

The purpose of the guidance system (GS) is to guide the missile to a point in space from which the reentry body (RB) will free-fall to a preselected target. To do this the GS must be able to perform the navigation and guidance routines needed to provide the missile with a commanded attitude throughout flight, a commanded thrust direction during equipment section flight, and certain discrete events (such as second-stage cutoff), which, in turn, initiate specific events during flight. The guidance system executes the flight program stored in the guidance computer and generates signals that steer the POSEIDON C3 missile to the position and velocity required for release of each reentry body.

Control during powered flight is provided by the guidance system (GS). The GS can accommodate all missile motions except those that existed before the guidance computer was activated. Prelaunch missile motions are, therefore, calculated by the fire control system (FCS) and are written into the guidance computer up to the time of launch. Calculations for the powered flight are based upon missile location (starting at the launch point), target location, GS errors, biases, and miscellaneous correction factors.

The goal of this chapter is to enable you to understand how the guidance system works with the FCS and how the different subsystems work together as one unit.

INERTIAL DEVICES

Inertial guidance is defined as: "A guidance system that guides the missile along a predetermined flight path where the position of the missile is constrained to that path after launch by devices wholly within the missile and totally independent of external sources of information." By definition, it is apparent that the missile contains all the components necessary for the operation of the guidance system. The guidance system must also be supplied prior to launch with all the information it needs to direct the missile along the flight path.

Future target position relating to the launch point must be known. And it follows that ship position and motion at the instant of launch must be established with a degree of accuracy at least equal to the required terminal accuracy of the missile. Where the missile time of flight is appreciable, the difficulty of computing a missile path to future target position and measuring missile motion, position, and attitude relating to the computed flight path is quite formidable. These measurements must be made with great precision for they spell the difference between a useful or a useless weapon system. For example, a missile may be traveling at 15,000 feet per second when the reentry body is released, yet a velocity error of only 1 foot per second in magnitude produces an impact error of approximately one-half mile in range.

The flight path followed by a fleet ballistic missile (FBM) is dependent on measurements of missile motions. These motions are detected and measured by sensors in the missile guidance system. Basically two types of sensors are used: gyroscopes, which detect angular displacements of the missile about the flight path; and accelerometers, which detect changes of linear motion along the flight path. Both types of sensors are inertial devices whose operating principles are governed by the physical laws of motion. Therefore, this section has a threefold purpose: it summarizes the physical laws involved, it describes in detail the operating principles and the general arrangement of the inertial devices, and it emphasizes the applications of these devices in the FBM equipment. The inertial devices are the dynamic heart of the FBM system and, as such, an understanding of them is essential to the FTB.

MOTION

Relative motion is the motion of objects in relation to each other. This is the type of motion we observe. For example, assume you are in a car traveling 50 miles per hour alongside a large truck traveling in the same direction and at the same speed. It would be difficult to sense your speed by observing the truck since the relative speed is zero. By shifting your sight to the roadside, you can obtain an idea of the speed of your car with respect to earth. However, earth is not stationary; it is in rapid motion as it travels in space with our solar system, orbits around the sun, and rotates on its axis. Therefore, we must establish a reference from which we can measure relative motion. Conventionally the terms *speed*, *velocity*, and *condition of rest* are measured in relation to the earth and the space about it. This area is called inertial space.

In general there are two types of motion: linear and angular. Linear motion is any motion in a straight line and is considered as a motion of translation of the object's center of gravity. Angular motion is considered as a motion of rotation about an axis. We will consider linear motion first.

LAWS OF MOTION

Newton's laws of motion are basic laws of physics. Even though the laws are fundamental, they are important enough to the study of the inertial devices used in the FBM to be included here.

Newton's first law of motion states: "A body at rest remains at rest, and a body in motion continues to move at a constant speed along a straight line unless acted upon in either case by an unbalanced force."

The first statement in this law is apparent from experience. The second statement is not quite so apparent since in everyday experience friction is always present to resist motion. However, if all forces could be removed, an object set in motion would continue to move indefinitely at a uniform speed unless acted upon by an unbalanced force. A force is a push or pull exerted upon an object. Thus, energy is applied to the object. And it follows that the forces acting on an object at rest or in uniform motion must be equal and opposite. In other words, they are in balance and will cancel each other. If these forces are not in balance, the object will accelerate.

Newton's second law of motion states: "An unbalanced force acting on a body causes the body to accelerate in the direction of the force, and the acceleration is directly proportional to the unbalanced force and inversely proportional to the mass of the body." This law in formula reads as follows:

$$a = \frac{F}{m}$$

where $\underline{a}$ equals acceleration, $\underline{F}$ equals the unbalanced force acting on the body, and $\underline{m}$ equals the mass of the body. The second law of motion establishes mathematically the relationship between the three factors involved with motion.

Newton's third law of motion states: "For every action there is an equal and opposite reaction, and the two are along the same line." This law deals with two bodies and forces. For example, a football when kicked has a restoring force set up in it which reacts upon the kicker's foot. The action (motion of the kicker's foot) is exerted on the ball, while the reaction (restoring force in the ball) is applied against the kicker's foot. It is the reaction force that propels the ball into flight. The action and reaction are exerted on separate bodies and therefore cannot cancel each other. For two forces to cancel, they must be exerted on the same body. This principle is fundamental to all motors but is more easily seen in reaction-type motors, such as jet and rocket motors.

Inertia

You may think of inertia as the opposition offered by a body to any change of motion; that is, an unbalanced force is required to give the body linear acceleration. The definition of inertia is, in fact, a restatement of the first law of motion. The property of inertia implies a broader concept of the definition of mass than mere quantities of matter. You may think of mass as the property of an object by virtue of which it possesses inertia. Let's examine the relation between the mass and the weight of an object. For any given mass the gravitational attraction of the earth varies with the geographical position or distance from the earth's center. This attractive force exhibited by the earth is called weight. As a result of this variation in the weight of the matter, it is necessary to use the following expression (Newton's second law) to define mass:

$$M = \frac{W}{g}$$

where $\underline{M}$ is mass, $\underline{W}$ is the weight, and $\underline{g}$ is the acceleration produced by the earth's attraction. Both $\underline{W}$ and $\underline{g}$ vary in such a manner as to keep $\underline{M}$ constant. It follows then that weight is a force acting on matter, and mass is a property of matter. As you move a mass around in Newton's universe, it contains the same amount of material.

Momentum

From the discussion of inertia and the first law of motion, it can be deduced that a body in motion possesses the tendency to remain in uniform motion. This tendency or property is called momentum, which is defined as "the product of the mass of a body and the body's velocity." It might be called "the quantity of motion" of a body and is the amount of kinetic energy in the body. Kinetic energy is sometimes referred to as the energy of motion. Momentum is a vector quantity and has the same direction as the velocity vector.

ANGULAR MOTION

A body rotating about a fixed axis, such as a flywheel on a motor shaft, does not move from one point to another along a straight line and consequently its motion is not linear. Different points on the flywheel describe concentric circles about the rotational axis. If the rotary motion is constant, we can compute angular speed by the formula:

$$\text{angular speed} = \frac{\text{angle swept through}}{\text{time}}$$

or symbolically,

$$\omega = \frac{\theta}{t}$$

where the Greek letter omega (ω) stands for angular speed, the Greek letter theta (θ) stands for angular displacement, and $\underline{t}$ stands for time.

A rotating body will continue to turn about a fixed axis at a constant angular speed unless acted upon by an unbalanced torque. Notice the similarity between this statement and the first law of motion. You can consider torque as the angular equivalent of force. Force acts in a straight line at or on a point, whereas torque occurs in a plane and is referred to as being applied about an axis. A torque is equal to the product of the force and the perpendicular distance from the axis of rotation to the line of action of the force. Expressed as a formula:

$$T = Fr,$$

where $\underline{T}$ equals torque, $\underline{F}$ equals force, and $\underline{r}$ equals the perpendicular distance or radius through which the torque is exerted. This radius is sometimes called the lever arm distance.

A torque applied to a rotating body will produce angular acceleration, which is symbolized by the Greek letter alpha (α). Angular acceleration is directly proportional to the torque exerted and indirectly proportional to the resistance the body offers to a change in its angular motion. This is in accordance with the second law of motion. But a torque is applied about the rotational axis through the lever arm distance. Consequently, the resistance to a change in the angular motion is affected by the mass of the body, the distribution of the mass, and the lever arm distance.

Moment of Inertia

Moment of inertia is a measure of the torque needed to bring about a change in the angular motion of a rotating body. Moment is defined as the tendency of energy acting on a body to produce angular motion, while inertia is the tendency of a body to resist a change in motion.

Moment of inertia, which is symbolized by the letter *I*, considers both the energy and the resistance involved in a change of motion of a rotating body. In linear motion inertia is considered to be along a straight line and, therefore, resistance to a change in motion can be computed by using the mass of the body. But this is not true of a rotating body whose axis of motion does not coincide with the lines of force. The distance between the point where the force is applied and the location of the resistance can be plotted along a radius of the body. Thus, we can consider this distance in somewhat the same manner as we do leverage.

Centrifugal and Centripetal Forces

In accordance with Newton's second law, a body in motion will not deviate from a straight line unless a lateral force is exerted upon it. When a locomotive arrives at a curve in the track, its forward motion causes the flanges on its wheels to press outwardly against the edge of the outer rail; and, conversely, the rail presses inwardly against the flanges. The locomotive changes direction as a result of this inwardly directed force and follows the curved track.

The lateral force required for motion along a curve also may be illustrated by a ball attached to a cord. (See fig. 2-1.) When the ball is whirled around at the end of the cord, the ball pulls outwardly, exerting a *centrifugal force* on the CORD. The result of the centrifugal force is to cause the cord to become taut and exert an inward pull, *centripetal force*, upon the BALL.

When an object follows a circular path at a constant speed, its velocity is constantly changing, not in magnitude (speed) but in direction (TANGENTIAL VELOCITY). Remember, velocity is a combination of speed and direction—a vector quantity.

As previously mentioned, centrifugal force is the force acting on the cord. If you are a passenger on the train as it goes around the curve, you will be very aware of the centrifugal force because you (and as it would seem, the train) would tend to be forced (accelerated) toward the outside of the curve. You are only aware of centrifugal force; from your point of view, only centrifugal force exists. A hobo standing next to the track would not be aware of this centrifugal force.

To the hobo, the track is pushing against the wheel flanges as the train makes the turn. The inertia of the train and its occupants (or the ball) make them want to continue in a straight line. The force of the rails against the wheels (or the cord on the ball) are examples of centripetal force. This force acting toward the center of the curve causes the moving train to change direction and travel in a curve. The force of the train on its occupants is another example of centripetal force. If you were standing in the aisle of the train as it turned, you would grab a pole or seat back for support. The force you exerted so your body would follow a curved path is centripetal force. The hobo only observes the results of centripetal force; from his point of view, only centripetal force exists.

You see things very differently than the hobo. You, as a passenger, are in the accelerating frame of reference. You feel only the centrifugal force. To you, centripetal force doesn't exist. The hobo standing next to the track is in the earth frame of reference, he observes only centripetal force. To him, centifugal force doesn't exist. You each observe what you do because each force exists in

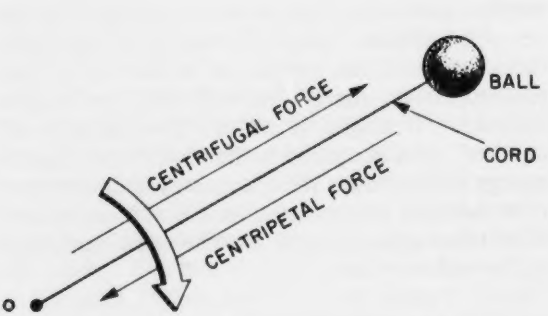


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Figure 2-1.—Forces acting on a ball whirled around at the end of a cord.

only one frame of reference and you are each in different frames of reference.

Any motion along a curve involves both centrifugal and centripetal forces. These forces are equal and opposite and are exerted in the plane that the curve lies. However, although equal, these forces cannot balance each other because each exists in only one frame of reference. They are not exerted upon the same object.

An unbalanced force always produces acceleration. The centripetal force acting upon a body in circular motion continually accelerates it toward the center of the circle. The body moves in a circle as a result of this inward acceleration combined with its forward motion.

The magnitude of the centripetal force is determined by several factors. These factors are the centripetal acceleration of the object (a), the velocity (speed and direction) along the circular path (v), the radius of the circular path (r), and the mass of the object (m).

According to Newton's second law, force equals mass times acceleration ($F = ma$). Centripetal acceleration is equal to the square of velocity divided by the radius ($a = \frac{v^2}{r}$). If we transpose these formulas for force (centripetal),

$$F = m \times \frac{v^2}{r} = \frac{mv^2}{r}$$

we can conclude that the magnitude of centripetal force is directly proportional to the mass or the square of the velocity and inversely proportional to the distance from the axis of the circular motion (radius).

Centripetal acceleration always takes place perpendicular to velocity. Likewise, centripetal force always acts perpendicular to velocity and toward the center or axis of rotation.

GEOPHYSICAL PROPERTIES

The prescribed flight path of a missile is within the sphere of influence of the earth. A network of forces exerted by the mass and motions of the earth act on the missile. For the missile to remain in its prescribed flight path, the inertial devices in the guidance system must be aligned to a reference point and compensations must be made for the effects of these forces. We will consider the natural forces acting on the missile.

Coriolis Effect

The earth rotates 360° each 24 hours. Because of this rotation, each point on the earth has the same angular velocity (15° per hour).

The tangential velocity of a point on the surface of the earth increases in relation to how far that point is from the earth's axis of rotation.

Coriolis effect is based on the facts that (1) different points on the earth can have different tangential (linear) velocities and (2) the difference between tangential velocities of two points near the poles is greater than that of two points near the equator. Because of these two facts, Coriolis effect is said to be a sine function of latitude. This simply means that Coriolis effect is zero at the equator and increases with latitude until it is maximum near or across either of the poles.

In figure 2-2, an object (objects shown as black squares) on the equator has a tangential velocity of about 1,000 miles per hour due to earth's rotation. The objects between the equator and the poles will have a considerably smaller tangential velocity. The objects on the earth's axis (poles) will have zero tangential velocity.

The Coriolis effect can cause an apparent lateral acceleration because of the latitude relationship between the launch point and the target. You must keep in mind that the target point also has an eastward tangential velocity the magnitude

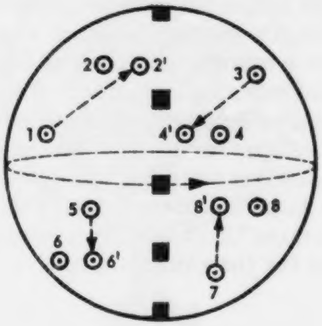

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Figure 2-2.—Coriolis effect in the Northern and Southern hemispheres.

of which is determined by its distance from the earth's axis.

Looking once again at figure 2-2, if we fire a missile from point 1 (higher east velocity) toward point 2 (lower east velocity) and do not correct for the Coriolis effect, the missile will be deflected to its right as shown by the dotted lines. In this case, the linear velocity of the launching point is greater than that of the target velocity. The launching point component of the velocity will cause the missile's deflection to the right, and cause it to strike at point 2′.

Now assume that we fire from point 3 (lower east velocity) to point 4 (higher east velocity), again failing to correct for the Coriolis effect. The missile will again be deflected to its right, landing at point 4′. In this case, the launch point has a smaller linear velocity than the target point.

From the foregoing, we can say that if the Coriolis effect is not corrected for, the missile will be deflected to its right in the Northern hemisphere because of the differences in linear velocity.

In the Southern hemisphere, the effect is reversed; that is, the missile is deflected to its left. This can be seen when firing from point 5 toward point 6 in the figure. The higher velocity at point 5 (relative to point 6) will cause the missile to be deflected to its left, landing at point 6′. If we fire in a northerly direction in the Southern hemisphere, the missile will still be deflected to its left as shown by points 7, 8, and 8′.

Therefore, we can say that if the Coriolis effect is not corrected for, a missile will always be deflected to its left in the Southern hemisphere.

Since the tangential velocity imparted to the missile at launch and displacement of the target due to earth's rotation and time of flight varies mainly by latitude, the magnitude of the Coriolis effect is said to be "latitude dependent." The Coriolis effect that results from launch point and target locations on earth has to be considered in computing targeting corrections. This must be done because the GS cannot sense, and therefore compensate for the Coriolis effect.

Gravity

The law of universal gravitation states, "Each particle of matter attracts every other particle with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them." Thus, bodies fall to the ground because of the attraction between the earth and the bodies. This attraction is the force of gravity, (symbolized by the letter g), and causes a body to accelerate while falling. Neglecting air resistance, all bodies fall with the same acceleration. At the surface of the earth, g is equal to 32.2 feet per second squared. This figure varies slightly at different locations on the surface of the earth because of its shape.

For any given object, there is a particular point through which the resultant of the weight forces will always pass regardless of the orientation of the object. This point is called the CENTER OF GRAVITY (C.G.) of the body. Hence, the weight of an object, although actually a system of parallel forces acting upon all its component parts, can be correctly represented by a single force acting downward at the center of gravity.

The gravitational force provides us with a convenient reference to orient the inertial devices in the missile guidance system. Assume that the earth is spherical in shape, its mass has a uniform density, and it is not in motion. Under these assumptions the center of gravity of the earth would coincide with its geometric center. The gravitational force exerted on the missile would be directed at all times toward a point located exactly at the earth's center. Thus, a plumb bob or pendulum that is free to align itself with the gravitational force would point toward the center of the earth. Therefore, a line through the center of the pendulum would be in the true vertical with respect to a line tangent to the surface of the earth. Once the vertical plane is established, we could use it to orient the missile guidance system with respect to the earth.

Unfortunately, the foregoing assumptions are not completely true. We know the earth is neither motionless nor perfectly round. The rotation of the earth on its polar axis once a solar day is the only motion of the earth we will consider. The other motions of the earth do not greatly affect the missile guidance system.

Particles at all points on the earth, other than the polar axis, will experience a force as a result of the earth's angular velocity. This force is a function of tangential velocity and is greatest at the equator, and diminishes to zero at the poles. The combined effect of this force and the gravitational force distorts the earth from a sphere into an oblate (flattened at the poles) spheroid shape known as an ellipsoid. The polar diameter of the earth is somewhat less than the equatorial diameter because of this force.

A pendulum not on the earth's polar axis would experience both the attraction of gravity and the force due to tangential velocity. The pendulum would indicate the local vertical, the combination of both forces, rather than the true vertical.

The force due to tangential velocity varies with latitude, being zero at the poles, which define the axis of earth's rotation, and maximum at the equator where the velocity is greatest. This force is always felt in a plane that is perpendicular to the earth's axis. At the equator, it coincides with the gravitational force so that the local vertical is not deflected from the true vertical. The magnitude of these combined forces, of course, would be equal to 1 g. It can be shown that the amount of deflection of the local vertical due to earth's rotation is greatest in the vicinity of latitude 45°.

In this discussion describing the determination of the local vertical, we did not consider variations in the density of the earth's mass. The pendulum discussed would also be deflected toward the more dense regions in its vicinity. An additional complication is the influence by other spatial bodies, such as the sun and the moon, on the complex pattern of gravitation over the earth. While this effect is small, it does influence the degree of deflecton of the pendulum from the true vertical.

The conclusion we can draw from the foregoing discussion is that a pendulous device will orient itself to the local vertical rather than the true vertical. A stable platform (discussed later in this chapter) is such a device.

Now we must consider how all this affects the inertial guidance system in the missile. The missile must travel great distances to accomplish its mission. The flight path of the missile is computed using the frame of reference established when the guidance system is oriented or erected to the local vertical at the launch point. The inertial devices of the missile's guidance system maintain this frame of reference throughout the flight and thus they are capable of measuring the changes in the missiles attitude and motion in relation to the prescribed flight path.

GYROSCOPES USED IN FBM GUIDANCE

The gyroscope, commonly called a gyro, has existed since the first electron was sent spinning on its axis. Electrons spin and show all the characteristics of a gyro, and so does the earth, which spins about its polar axis at over 1,000 miles per hour at the equator. The earth's rotation about its axis provides the stabilizing effect that keeps the North Pole pointed within one degree of Polaris (the North Star).

Any rapidly spinning object—a top, wheel, an airplane propeller, or a spinning projectile—is fundamentally a gyroscope. Strictly speaking, however, a gyroscope may be defined as a mechanical device containing a spinning mass which is universally mounted; that is, mounted so it can assume any position in space. Figure 2-3 shows a model of a gyro. As you can see, a heavy wheel (rotor) is mounted so that its spin axis is free to turn in any direction. The wheel can spin about axis X, it can turn about axis Y, and

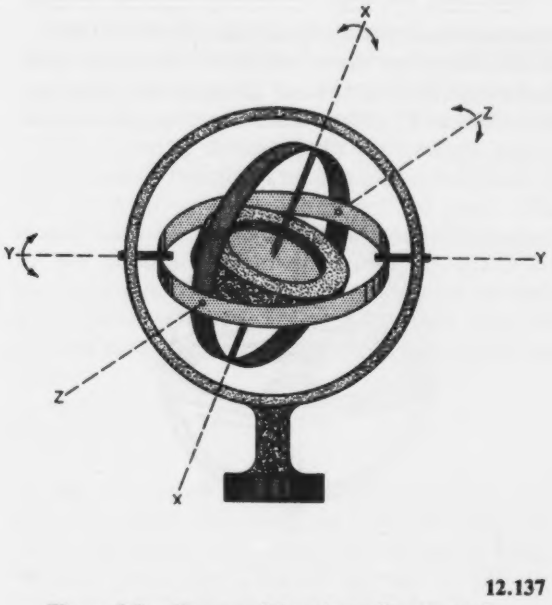

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Figure 2-3.—Gyro model, universally mounted.

finally turn about axis Z. With this mechanical arrangement, the spinning wheel can assume any position in space.

BASIC PROPERTIES OF GYROSCOPES

Gyroscopes have two properties which make them useful in weapon control:

1. The axis of rotation (spin axis) of the gyro wheel tends to remain in a fixed direction in space if no force is applied to it (rigidity).
2. The axis of rotation has a tendency to turn at a right angle to the direction of an applied force (precession).

The idea of maintaining a fixed direction in space is simple to illustrate. When any object is spinning rapidly, it tends to keep its axis pointed always in the same direction. A toy top is a good example. As long as it's spinning fast, it stays balanced on its point. Because of its gyro action, it resists the tendency of gravity to change the direction of its axis. You can think of many more examples. A bicycle is easier to balance at high speed than when it's barely moving. At high speed, the bicycle wheels act as gyros and tend to keep their axes parallel to the ground.

Note that it's easy to MOVE the axis as long as you keep it pointing in the SAME DIRECTION. The gyro resists only those forces that tend to change the direction of its axis. In a bicycle, since the axis of rotation is horizontal, the wheels will resist any force that tends to tilt the wheel over or turn it.

If you can obtain a gyroscope top, you can do some instructive experiments with it. Hold the gyro top with its axis vertical (fig. 2-4) and start it spinning. As long as it is spinning fast, it will stay balanced. You can balance it on a string or on the point of your finger; the axis will stay vertical as long as the top is spinning fast.

Now stop the gyro top and turn its axis horizontal. Start it spinning again and balance one end on a pivot. (See fig. 2-5.) If the top is spinning fast, it won't fall. Its axis will stay horizontal, resisting the tendency of gravity to change its direction. But while the gyro will resist the force that gravity applies to it, it will still RESPOND to that force. And it responds by moving its axis at a RIGHT ANGLE to the APPLIED force.

Figure 2-6 is another view of the same gyroscope. Its far end is still balanced on the pivot. Gravity is pulling down on the gyro. If the gyro rotor is turning in the direction shown by the arrow, then the near end of the frame will turn to the left. (If the rotor is turning in the opposite direction, the frame will turn to the right.) The axis will stay horizontal, but the gyroscope will

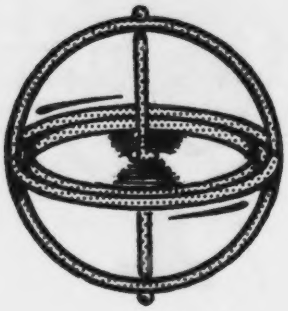

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Figure 2-4.—A gyroscope top.

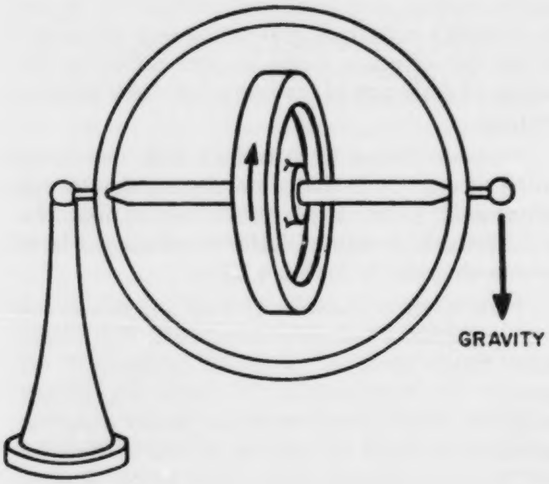

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Figure 2-5.—Gyro top with axis horizontal.

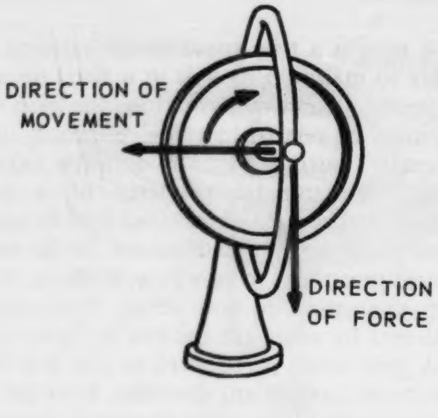

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Figure 2-6.—Gyro precession.

respond to the force of gravity by rotating around the pivot.

Gyro action may be summarized in this fashion: A spinning gyro tends to keep its axis pointing in the same direction. This is called rigidity. If you apply a force that tends to change the direction of the spin axis, the axis will move at a right angle to the direction of the applied force. If the axis is horizontal and you try to tilt it, the axis will turn. If the axis is horizontal and you try to turn it, the axis will tilt. This second characteristic of a gyro is called precession.

BASIC GYRO ELEMENTS

The gyro shown in figure 2-7 is a basic universally mounted gyro. The components are rotor, inner gimbal, outer gimbal, and base or support. The three major axes of any gyro are the spin, torque, and precession. The spin axis is, of course, the axis in which the rotor spins. The torque axis is the axis about which the disturbing force is applied. The precession or tilt axis is the axis the gyro turns about as a result of the force applied to the torque axis.

There are several ways of naming the axes of a gyro. The name assigned an axis is usually taken from the reference line or plane it has established. Some of the names are north-south, east-west; vertical-horizontal; roll, pitch, and yaw; input, output; torque, sensitive.

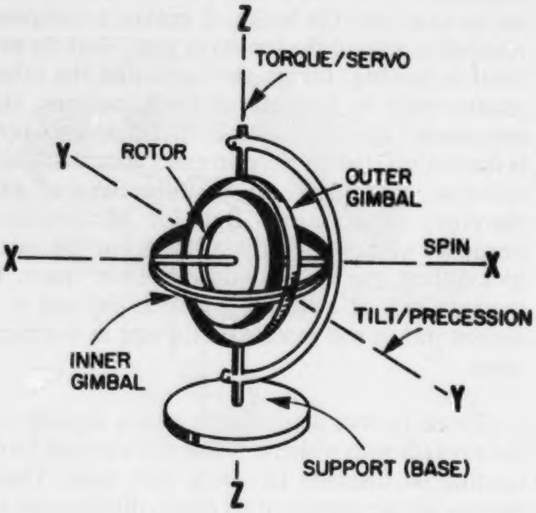

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Figure 2-7.—Basic universally mounted gyro.

The gimbals are devices that permit the rotor to incline freely in any direction and retain that position when the support is tipped or repositioned. Note that in figure 2-7 the support may be moved about all three axes without the rotor position being disturbed.

As previously discussed, gravity is a force that acts along parallel lines upon each particle of matter that makes up the gyro. Each force acts independently of all other forces, but force is a vector quantity having both a direction and a magnitude. Therefore, we can plot a resultant of the forces of gravity acting on the gyro. The magnitude of this single force is exactly equivalent to the separate parallel forces. Its point of application is called the center of gravity. To have a balanced gyro, the center of gravity must be located at the intersection of the three axes of the gyro.

Rigidity

As previously discussed, a gyroscope is a spinning body that tends to keep its spin axis rigidly pointed in a fixed direction in space. What do we mean by FIXED DIRECTION IN SPACE? A fixed direction on earth is by no means fixed in space, because the earth turns once on its axis every 24 hours. It makes a complete revolution around the sun every year. And the sun itself is moving, taking the earth and the other planets with it. Because of these motions, the expression "fixed direction in space" as used here is theoretical. If that were an exact statement, our universe would have to be unaccelerated and therefore nonrotating. But for all practical purposes we can say this: a line from the earth to a distant star is a fixed direction in space. If the spin axis of a spinning gyro is pointed at a distant star, it will remain on the star as the earth turns.

Three factors determine a gyro's rigidity, or the strength with which it resists any external force tending to displace its rotor spin axis. These factors are the weight of its rotor, distribution of its weight, and its rotor speed.

We can consider the gyro as an enclosed mechanical system. The energy in the system is equal to the input energy. Hence the energy necessary to spin the gyro rotor is contained in the rotor as angular momentum. The heavier the gyro rotor, the larger the torque necessary to spin it, and the greater the angular momentum of the rotor. If we have two rotors with identical shapes but of different weights spinning at the same velocity, the heavier of the two will be more rigid in its spin axis since it contains the greater angular momentum.

To understand the effect of weight distribution in a rotor of a gyro, consider two rotors of the same weight, with the diameter of one, half that of the other. Now, when we spin both of these rotors at the same speed, we find that the rotor with the greater diameter is much more rigid than the one with the smaller diameter. Next we find that we can make both rotors equally rigid by causing the rotor with the smaller diameter to spin faster than the larger rotor. Thus, rigidity is dependent upon both speed and distribution of weight. The weight of the larger rotor being farther away from the axis of spin causes it to be more effective for rigidity. In physics it is said that the weight of the larger diameter rotor has the greater "moment of inertia."

Precession

A gyro is a true space device relating to its ability to maintain its axis in a fixed direction. To provide useful information, the gyro's spin axis must be related to some reference, usually the earth's surface. This is done by using the second fundamental property of a gyro—precession. The gyro is precessed until its spin axis is pointed in the desired direction. So far we have covered precession in very general terms. We will cover this action in more detail. Precession can be shown by using the models in figure 2-10.

A gyro wheel is mounted so that it is free to align its spin axis in any direction. Here the wheel rotates in a flat loop called the gyro case or inner gimbal. The gyro case is pivoted in the gimbal ring, and the gyro can swing about the Z axis. The gimbal ring itself turns on pivots, which connect it to the fork (support), permitting the gyro to tilt from side to side about the Y axis.

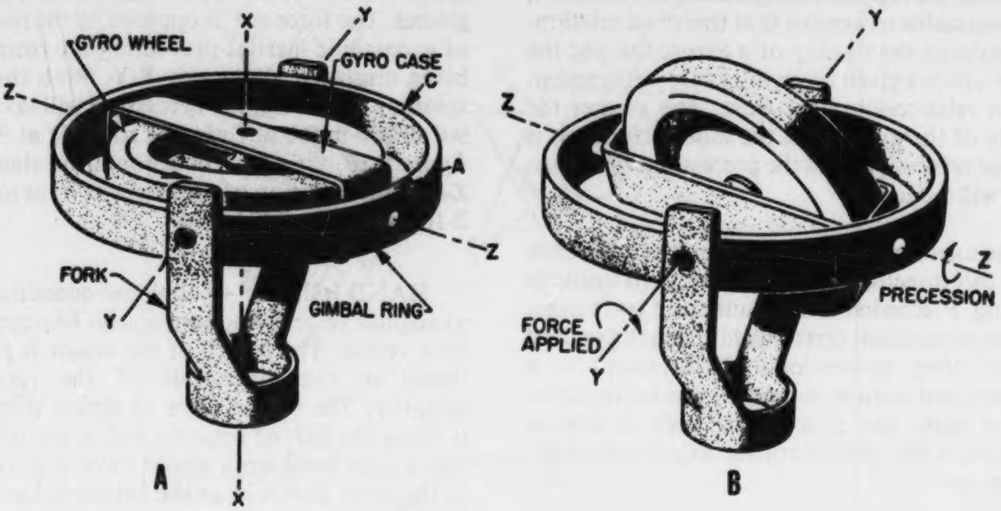
Regardless of how the fork is placed, the spinning gyro wheel is free to lie in any given plane. That's why it is called a free gyroscope in this mounting.

To show the effect of precession, push down on the gimbal ring at point A at the nearer end of Z-Z axis. (See fig. 2-8, view A.) You would expect the ring to tilt around the Y-Y axis. Instead of rotating about the Y-Y axis as you might expect, however, the gyro case will turn about the Z-Z axis. You can see the effect of precession in figure 2-8, view B.

Similarly, going back to figure 2-8, view A, suppose you push sideways on the top of the X-X axis (the spinning axis of the gyro), trying to rotate the wheel around the Z-Z axis. Then, instead of rotating about the Z-Z axis, the gimbal ring will turn around the Y-Y axis.

If you push down at point C on the gimbal ring (fig. 2-8, view A) midway between the Y-Y and Z-Z axes, you will find that the gimbal ring rotates around the Y-Y axis, and that the gyro case rotates around the Z-Z axis. The total effect causes the gyro wheel to turn around a line lying from point C through the center of the gyro wheel.

Here's a rule that applies to all spinning gyros: THE GYRO WILL ALWAYS PRECESS AT RIGHT ANGLES TO THE DIRECTION OF THE APPLIED FORCE. Look at figure 2-8, view A, again. If you keep pushing down on the



A. GIMBAL MOUNTING
B. PRECESSION

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Figure 2-8.—Gyro action.

gimbal ring at point A, the gyro case will keep turning until the spin axis of the gyro wheel is horizontal. Then there will be no further precession. At this point the gyro wheel is spinning in the same direction in which the applied force is pushing.

Here's another rule: A GYRO ALWAYS PRECESSES IN A DIRECTION TENDING TO LINE ITSELF UP SO THAT ITS ROTOR SPINS IN THE SAME DIRECTION THAT THE APPLIED FORCE IS TRYING TO TURN IT. In other words, the spin axis chases the torque axis. When the two come into coincidence, precession no longer takes place.

It should be noted that most forces, when applied to the gyro mounting, do not cause precession. For instance, you can swing the fork around in any direction, and the motion will merely be taken up in the Y-Y and Z-Z axes. Similarly, a force applied lengthwise along one of the axes will have no effect. ONLY THOSE FORCES TENDING TO TILT THE GYRO WHEEL ITSELF WILL CAUSE PRECESSION.

Let's consider further the important characteristic of gyroscopic precession, using another method to illustrate this fundamental property. As it is impossible to make bearings entirely free of friction, in most gyros, friction is kept to a minimum, and the rotors are designed to have a great deal of rigidity. Whatever friction remains is small in comparison to the great rigidity of the heavy, rapidly spinning rotor, and its effect upon the gyro is extremely slight.

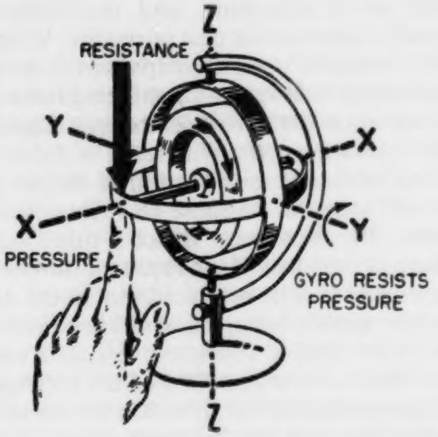
An operating gyro will resist a force that attempts to change the direction of its spin axis, but it will move in response to such a force or pressure. The movement is not a direct one in response to the force; it is a resultant movement. The gyro axis will be displaced, not in the direction of the applied force, but in a direction at right angles to the applied force, and in such a way as to tend to cause the direction of the rotation of the rotor to assume the direction of the torque resulting from the applied force.

For a given force, the rate of precession is governed by the weight, shape, and speed of the wheel. These factors are the same as those that determine the rigidity of a gyroscope. Therefore, it is reasonable to assume that there is a relationship between the rigidity of a gyroscope and the rate at which a given force will cause it to precess. Such a relationship does exist. The greater the rigidity of the gyroscope, the more difficult it is to cause precession, and the precession for a given force will be less.

The location of the precessional axis depends upon the direction in which the gyro rotor is spinning. Precession is the resultant of two forces: angular momentum (gyro rigidity) and the applied torque. Since precessional displacement is a resultant and angular momentum is in the direction of spin, the precessional axis is always offset from the applied torque axis in the direction of spin.

The forces acting on a gyroscope may be represented graphically as acting on the rotor itself, spinning freely in space, with a plane containing each of the axes of freedom.

For example, when a force is applied upward on the inner gimbal, as shown in figure 2-9, the force may be visualized (using figure 2-10, view A) as being applied in an arc about axis Y-Y until it contacts the rim of the rotor at F. The effect produced by the force is equivalent to that produced by a force applied upward to the inner gimbal. The force at F is opposed by the resistance of gyroscopic inertia, preventing the rotor from being displaced about axis Y-Y. With the rotor spinning clockwise, the precession will take place 90° ahead in the direction of rotation at P, as in figure 2-10, view A. The rotor turns about axis Z-Z in the direction of the arrow at P, as in figure 2-10, view B.



12.142

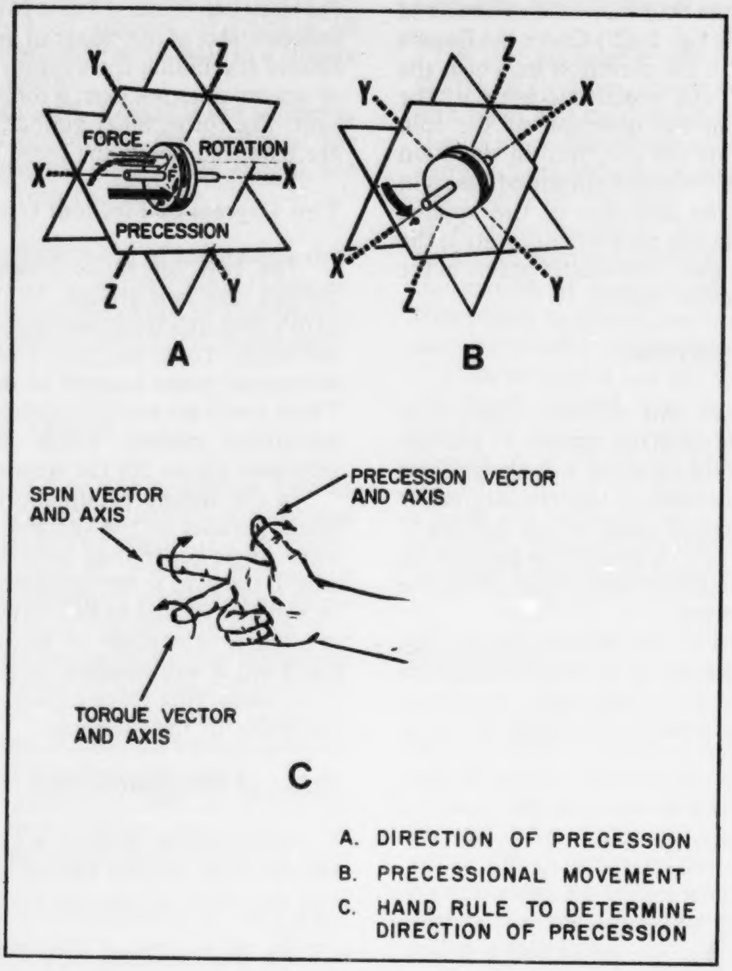
Figure 2-9.—Force applied to a gyro.

HAND RULES.—Rotational quantities, such as angular velocity and torque, can be represented by a vector. The length of the vector is proportional to the magnitude of the rotational quantity. The vector's line of action (direction) is along the axis of rotation and in the direction that a right-hand screw would travel if it is rotated in the same direction as the rotational quantity. For example, a gyro rotor's spin vector is perpendicular to the rotor's plane of rotation (along the rotor's spin axis). When the rotor spins in a clockwise direction, the screw would move into the rotor when moved in the clockwise direction, as shown in figure 2-11. If we reverse the rotor's direction of spin, the screw would move out of the rotor when moved in the counterclockwise direction.

The motions of a gyroscope can be analyzed by three basic vector quantities: (1) spin, the angular velocity of the gyro rotor, (2) torque, the rotary motion applied to change the direction of the rotor axis, and (3) precession, the resulting angular velocity of the rotor axis when torque is applied.

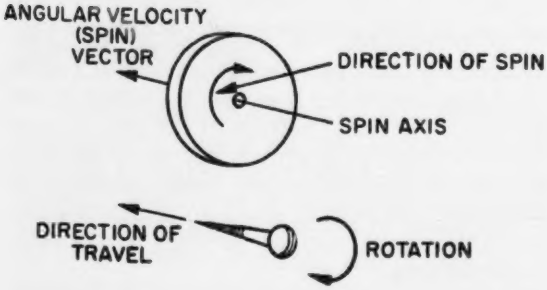
All three motions are rotary (angular). They can be represented by vectors pointing in such a direction that the rotary motion is clockwise when looking in the direction of the vector.

A convenient rule for determining the direction of procession is by the use of the fingers of the right hand. The three vectors listed above may be represented by arranging the thumb, forefinger, and middle finger of the right hand mutually perpendicular as shown in figure 2-10, view C. The thumb points in the direction of the precession vector, the middle finger points in the direction of the torque vector, and the forefinger


Y
Z
FORCE
ROTATION
X
F
X
PRECESSION
Z
Y
A
Z
Y
X
X
Z
Y
B
SPIN VECTOR AND AXIS
PRECESSION VECTOR AND AXIS
TORQUE VECTOR AND AXIS
C
A. DIRECTION OF PRECESSION
B. PRECESSIONAL MOVEMENT
C. HAND RULE TO DETERMINE DIRECTION OF PRECESSION

12.143

Figure 2-10.—Rules of precession.


ANGULAR VELOCITY (SPIN) VECTOR
DIRECTION OF SPIN
SPIN AXIS
DIRECTION OF TRAVEL
ROTATION

12.142

Figure 2-11.—Vector lines of action (direction).

points in the direction of the spin vector. You can consider these vectors as the axes about which angular motion takes place. If you look in the direction of the pointed fingers and thumb you can visualize that all the rotary motions are clockwise as indicated in figure 2-10, view C.

The three-finger rule is useful for analyzing any gyroscope motion problem because if the directions of any two of the three vectors are known, the direction of the third vector can be found, and the motion around this vector may be determined.

Another hand rule determines the direction of the spin vector. (See fig. 2-12.) Curve the fingers of the right hand in the direction in which the rotor is turning as if you intended to grasp it. The thumb will point in the direction of the spin vector. A similar rule will give you the direction of the torque vector. With the fingers of the right hand wrapped in the direction of the applied torque (the direction the gyro would rotate if the rotor were not spinning), the thumb points in the direction of the torque vector.

DEGREES OF FREEDOM

A gyro can have two different degrees of freedom, depending upon the number of gimbals in which it is supported and the way the gimbals are arranged. Do not confuse the term *degrees of freedom* with an angular value such as degrees of a circle. The term as it is applied to gyros is an indication of the number of axes about which the rotor is free to precess.

A gyro mounted in two gimbals usually has two degrees of freedom. When two gimbals are employed, it is said to be universally mounted. This arrangement provides two axes about which the rotor can precess. These two axes and the spin axis intersect at the center of gravity of the entire system (excluding the support). Thus, the force of gravity does not exert a torque to cause precession. The rotor, inner gimbal, and outer gimbal are balanced about the three principal axes.

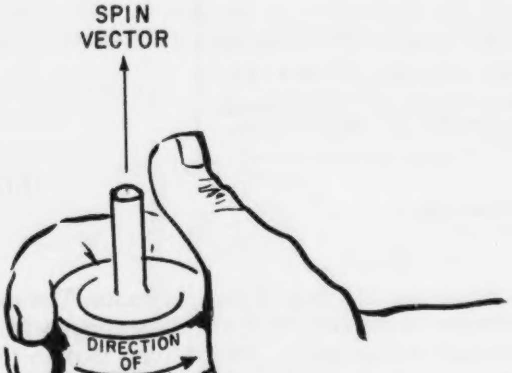


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Figure 2-12.—Determining spin vector direction.

Two Degrees-of-Freedom Gyros

The two degrees-of-freedom gyros can be divided into two groups. In the first group the gyro's spin axis is perpendicular to the surface of the earth. Thus, the gyro's rotor will spin in a horizontal plane tangent to the earth's surface. These gyros are used to establish the vertical and horizontal planes, which are the stabilized reference planes for the weapon control system.

In the second group the gyro's spin axis is either parallel to the surface of the earth or at some angle other than perpendicular. The spin axis of the gyro in the gyrocompass is maintained in a plane parallel to the surface of the earth. It is aligned in a plane of north-south meridian. Once set, it will continue to point north as long as no disturbing force causes it to precess out of the plane of the meridian.

Effect of Mechanical Drift

A directional error in a gyro is produced by random inaccuracies caused by mechanical drift and the effect of the earth's rotation (apparent drift).

We shall see later how it is corrected for in the equipment. First, let's consider the causes of mechanical drift.

There are three general sources of mechanical drift:

1. Unbalance. A gyro often becomes dynamically unbalanced when operated at a speed or temperature other than that for which it was designed. The static balance of the gyro is upset when its center of gravity is not at the intersection of the three major axes. Some unbalance of both types will exist in any gyro since manufacturing processes cannot produce a perfectly balanced gyro.

2. Bearing friction. Friction in the gimbal bearings results in loss of energy and incorrect gimbal positions. Friction in the rotor bearings

causes mechanical drift only if the friction is not symmetrical. An even amount of friction all around in a rotor bearing results only in a change of the rate of rotation.

3. Inertia of gimbals. Energy is lost whenever a gimbal rotates because of the inertia of the gimbal. The greater the mass of the gimbal, the greater the drift from this source.

The complete elimination of mechanical drift in gyros appears to be an impossibility. However, by proper design it has been kept to a minimum. Any error which still exists can be corrected.

Keeping the Gyro Vertical

A two degree-of-freedom gyroscope with its spinning axis vertical to the earth's surface and parallel to the direction of gravity is a direction-indicating device. Once set, it would continue to point in the vertical as long as no disturbing forces caused it to precess from this position. Given time it will precess from the vertical. The disturbing forces caused by apparent and mechanical drift are always present. A gyro-erection system is necessary to find and maintain a vertical position in a two degree-of-freedom gyroscope.

To make a gyroscope into a direction-indicating device that indicates accurately at all times, the following requirements must be met:

1. Torques must be provided of the correct magnitude and direction to precess the gyro in such a manner that the spinning axis is brought to the desired direction after the rotor has been set spinning.
2. Torques must be provided to precess the gyro back to the required position at the proper rate and direction to cancel the effects of apparent and mechanical drift.

The torques required to produce the proper precession to convert the gyro into a direction-indicating device are provided by an erecting system. Erection may be accomplished pneumatically, mechanically, or electrically, depending on the type of power available, and usually acts in response to the force of gravity. Specific erection systems are many and varied. We will discuss some of the systems later.

One Degree-of-Freedom Gyro

A gyro enclosed in one gimbal usually has one degree of freedom, freedom of movement back and forth at a right angle to the spin axis. You should know something about the application of gyros in a guided missile, so let's put one of these one-degree-of freedom gyros in a missile and observe its operation. We will mount it so that its axis of spin is parallel to the axis of travel of the missile. It is mounted now much like the flywheel in an automobile. It is spinning, and we have mounted it so that it can swing right to left. We can say that it has one degree of freedom. If the missile should nose up or down, the gyro would be forced to move exactly as the missile does in these directions. However, if the missile should turn left or right, the gyro would not change its attitude since it has freedom of motion in these directions. The spin axis would be fixed in the original direction of missile flight.

Rate Gyros

Rate gyros are used in the fire control and missile fields to detect and measure the angular rate of change of position of an object.

Rate gyros found in missile equipment may be called by different names, depending on which OP or other reference you are reading. Nevertheless, no matter what name is applied to a gyro that measures rate of change, it can be called a rate gyro.

Like the free gyro, the rate instrument contains a mechanical system consisting of the spinning rotor and associated gimbal system. It differs in that it has one gimbal, so that one degree of freedom is obtained. Further, the rotor is restrained by some means, usually a spring, when it is precessed.

Rate-of-Turn Gyro

A rate-of-turn gyro is nothing more than a simple gyroscope that is installed to take advantage of the principle of precession. You should remember that, among other factors, the rate of precession of a gyro is proportional to the force attempting to precess the unit.

Look at the gyro installation in figure 2-13, view A. This gyro has one degree of freedom. Movement about the Z-Z axis (input axis) is controlled by positioning the case with an attached handle. If you attempt to change the plane of rotation of the gyro by rotating the case about the Z-Z axis, the gyro will precess as shown in figure 2-13, view B. From what you have learned earlier in this chapter, the gyro does not appear to be obeying the rules for precession. However, turning the gyro case has the same effect as applying a torque on the spin axis parallel to the X-X axis. This is illustrated by arrow F in figure 2-13, view B. The direction of precession may be determined by using the right-hand rule discussed earlier.

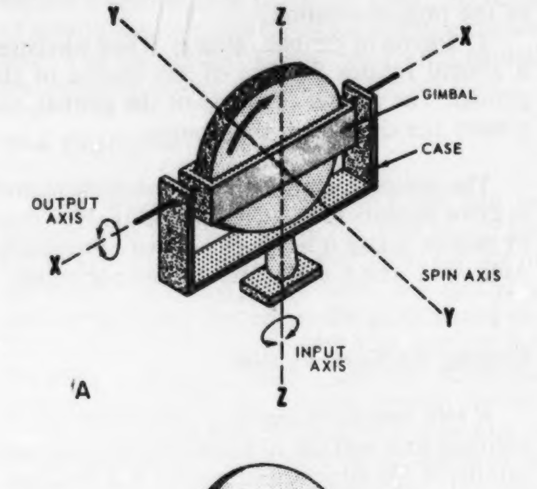
The torque applied at F will cause the gyro to precess at right angles to the torque. Likewise, attempting to turn the gyro case will cause the same result. The gyro will precess as shown by the arrows, around the X-X axis (output axis).

Since the rate of precession is proportional to the applied force, you can increase the rate of precession by increasing the speed with which you are moving the handle (fig. 2-13, view C). In other words, you have a rate-of-turn gyro. The faster you turn the handle, the more the gyro will precess, for the amount of precession is proportional to the rate at which you are turning the gyro case.

This characteristic of a gyro, when properly used, fits the requirements needed to sense the rate of motion about the missile's roll, pitch, and yaw axes.

Figure 2-14 shows a method of restraining the precession of a gyro to permit the calculation of an angle. A pair of springs have been attached to the crossarm of the output shaft. These springs serve to restrain the free precession of the gyro. The gyro may use other types of restraint, but no matter what type of restraint is used, the gyro is, in effect, harnessed to produce some useful work.

As a gyro precesses, it exerts a certain force that is proportional to the momentum of the spinning wheel and the applied force. For example, suppose you rotate the gyro case (fig. 2-14) at a speed corresponding to a horizontal force of 2 pounds at F. Obviously, the gyro will precess; and as it does, it will cause the crossarm to pull up on spring A with a certain force, say



A. RATE-OF-TURN GYRO MOUNTING
B. RATE-OF-TURN GYRO PRECESSES
C. AMOUNT OF PRECESSION IS PROPORTIONAL TO THE RATE-OF-TURN

12.152

Figure 2-13.—Rate-of-turn gyro.

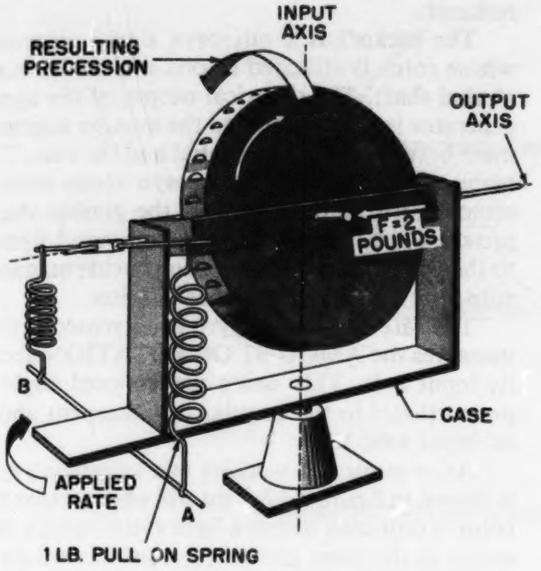


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Figure 2-14.—Precession of a spring restrained rate-of-turn (rate) gyro.

1 pound. (This amount of force would vary with the length of the crossarm.)

If you continue to turn the gyro case at this rate, the precession of the gyro will continually exert a pull on the spring. More precisely, the gyro will precess until the 1 pound pull of the crossarm is exactly counterbalanced by the tension of the spring, it will remain in a fixed position as shown in figure 2-14. That is, it will remain in the precessed position as long as you continue to rotate the gyro case at the same, constant speed.

When you stop moving the handle, it is equivalent to removing the force at F, and the gyro stops precessing. The spring is still exerting a pull, however, so it pulls the crossarm back to the horizontal.

Suppose you now rotate the gyro case at a speed twice as fast as before and in the same direction. This will be equal to a 4 pound force applied at F and a resulting 2 pound pull by the crossarm on spring A. In this situation the gyro will precess twice as far before the tension on the restraining spring equals the pull on the crossarm.

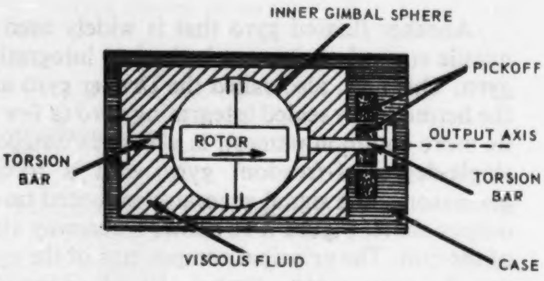

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Figure 2-15.—Torsion bar-restrained floated rate gyro.

Another type of rate gyro widely used in missile equipment is the floated gyro unit. This unit generally uses a restraint known as a torsion bar. The advantage of the torsion bar over the linear spring is that the torsion bar needs no lever arm to exert torque. The torsion bar is mounted along the output axis (fig. 2-15), and produces restraining torque in either direction by twisting instead of pulling. Also, there is no gimbal bearing friction to cause interference with gyro operation.

The viscous fluid surrounding the rotor serves to provide protection from shock and performs the function of damping the oscillations resulting from sudden changes in the angular rate input. In this gyro the inner gimbal displacement must be measured with some type of electrical pickoff. As the gyro case is rotated about the input axis, clockwise or counterclockwise, a precession torque will be developed about the output axis that will cause the inner gimbal to exert torque against the torsion bars. The torsion bars provide a restraining torque proportional to the amount of the inner gimbal's displacement. When the exerted gimbal torque is exactly opposed by the restraining torque provided by the torsion bars, the inner gimbal displacement will be proportional to the rate of rotation of the gyro case about the input axis. The pickoff measures this displacement and provides a signal whose amplitude and polarity (or phase) represent the direction and magnitude of the input angular velocity.

The important point to remember is that the "rate" gyro measures the RATE OF ROTATION ABOUT ITS INPUT AXIS.

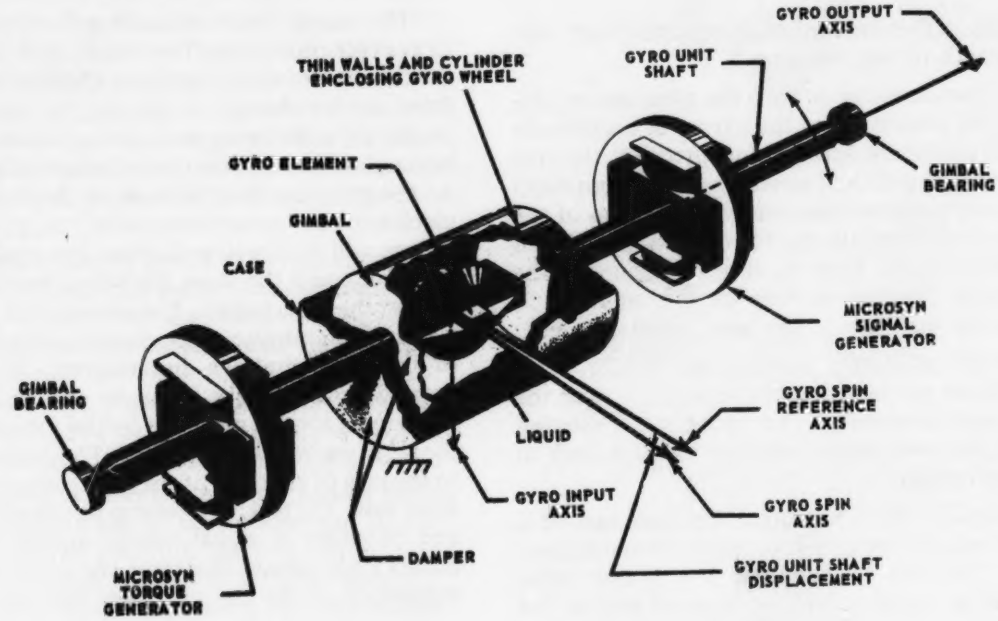
Rate Integrating Gyro

Another floated gyro that is widely used in missile control equipment is the rate integrating gyro. This unit, also called the Draper gyro and the hermetically sealed integrating gyro (a few of its more common names), is a viscous damped, single-degree-of-freedom gyro with a torque generator and a signal generator mounted on its output shaft. Figure 2-16 shows a cutaway view of the unit. The principal components of the gyro are the gyro rotor, gimbal, signal generator, torque generator, and the viscous damping fluid. The gyro rotor and stator are in a sealed cylinder filled with a gas, usually helium. The gas serves to transfer heat generated by the gyro stator windings to the surface of the cylinder. The closed metal cylinder acts as the inner gimbal and is mounted on precision bearings. The space between the gimbal and case is filled with a viscous fluid of high specific gravity. The high specific gravity of the fluid provides neutral buoyancy to the inner gimbal and its shaft. This reduces the gimbal bearing friction. In this way mechanical drift caused by friction is greatly reduced.

The pickoff is a microsyn signal generator whose rotor is attached to one end of the inner gimbal shaft. The electrical output of the signal generator is proportional to the angular displacement between the inner gimbal and the case. The torque generator, also a microsyn whose rotor is attached to the other end of the gimbal shaft, provides a means of applying command signals to the gyro. The microsyns also provide magnetic suspension to further reduce friction.

The rate integrating gyro is a gyroscope that measures the AMOUNT OF ROTATION about its input axis. This unit's precessional angle is proportional to the angular displacement about its input axis.

An example of a working rate-integrating gyro is shown in figure 2-17. You will observe that the rotor is mounted within a light metal sphere that serves as the inner gimbal (1), and this sphere is floated in a viscous fluid (2) inside the cylindrical case. High quality bearings are incorporated in this gyro to allow a near frictionless movement


GYRO OUTPUT AXIS
THIN WALLS AND CYLINDER ENCLOSING GYRO WHEEL
GYRO UNIT SHAFT
GIMBAL BEARING
GYRO ELEMENT
GIMBAL
CASE
MICROSYN SIGNAL GENERATOR
GIMBAL BEARING
GYRO SPIN REFERENCE AXIS
LIQUID
GYRO INPUT AXIS
GYRO SPIN AXIS
DAMPER
GYRO UNIT SHAFT DISPLACEMENT
MICROSYN TORQUE GENERATOR

12.154

Figure 2-16.—Floated gyro unit.

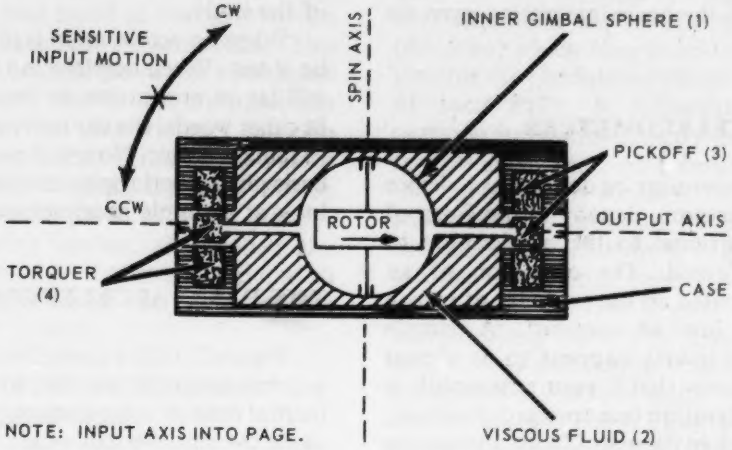


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Figure 2-17.—Working example of the rate integrating gyro.

of the inner gimbal about the output axis. A pickoff (3) is attached to the inner gimbal and the case to measure the displacement of the inner gimbal with respect to the case. The pickoff provides a signal whose amplitude and polarity (or phase) indicate that direction and amount of precession.

A torquer motor (4) on the opposite end of the inner gimbal axis is supplied with signals that apply various amounts of torque to the inner gimbal sphere. These varying amounts of torque are used to compensate for gyro drift, unwanted input rotation (earth's rotation), and other undesired quantities.

The rate integrating gyro is sometimes used in inertial navigation to stabilize a platform upon which the components of the system are mounted (fig. 2-18). Stabilization is accomplished by installing the gyro on a platform in such a manner that the input axis of the gyro is parallel to the axis of rotation of the platform. Any motion of the vehicle (in which the navigation system is installed) that tends to rotate the platform about its axis will be sensed by the gyro, and the gyro will precess about its output axis. The gyro pickoff will send a signal to the platform's servo amplifier, which will result in an amplifier output that will rotate the servomotor, driving the platform (relative to the vehicle) in a direction opposite to the direction of vehicle rotation. The platform will be driven until the gyro pickoff signal is zero.

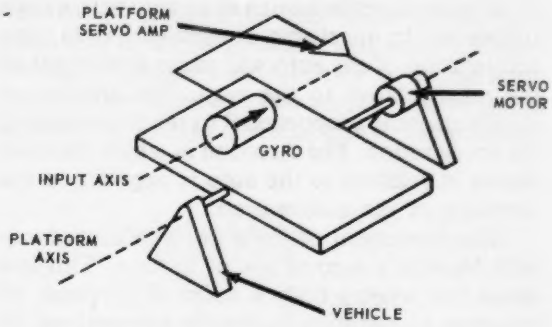

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Figure 2-18.—Simple platform stabilizing system.

The platform, therefore, moves in relation to the vehicle, but remains stationary with respect to the reference plane of direction. In the example shown, the platform will remain horizontal regardless of vehicle motion about the platform axis.

The rate-integrating gyros used in the FBM weapon systems are called the inertial-reference integrating gyro, the reduced-excitation, inertial-reference integrating gyro, which is smaller and more accurate, and the miniature-integrating gyro. The principles of operation of these gyros are identical with the basic-integrating gyro we just described.

ACCELEROMETERS

An accelerometer may be defined as a device that gives an indication, usually in the form of a voltage, proportional to the acceleration to which it is subjected. The operation of an accelerometer is based on the property of inertia (Newton's first law of motion). A simple demonstration of inertia happens to us almost every day. You know that if your automobile is subjected to acceleration in a forward direction, you are forced back in the seat. If your auto comes to a sudden stop, you are thrown forward. When your auto goes into a turn, you tend to be forced away from the direction of the turn—that is, if your auto turns left, you are forced to the right, and vice versa.

If we replace the human in an auto with a mass suspended in an elastic mounting system, any acceleration of the auto will cause movement of the mass relative to the auto. The amount of displacement is proportional to the force causing the acceleration. The direction in which the mass moves in relation to the auto is opposite to the direction of the acceleration.

The movement of the mass is in accordance with Newton's second law of motion. This law states that when a body is acted on by force, its resulting acceleration is directly proportional to the force and inversely proportional to the mass of the body.

When no acceleration is present, the mass will be at rest. When acceleration is present, the mass will lag in proportion to the acceleration force. In other words, the car moves but the mass wants to remain at rest. Now that we have discussed the basic physical principles involved, let's take a close look at a simple accelerometer.

THE BASIC ACCELEROMETER

Figure 2-19 is a simplified drawing of a basic accelerometer. It consists of a mass, called the inertial mass or seismic mass, which is free to slide along the sensitive axis within the case. The movement of the mass is limited by the springs. When the case is accelerated, the seismic mass, because of its inertia, tends to remain stationary. This results in a relative movement of the mass with respect to the case. When the stretch of the springs overcomes the inertia of the mass, the springs cause the mass to stop moving with respect to the case. The displacement of the mass with respect to the case is directly proportional to the acceleration of the case. When the case stops accelerating, the springs return the mass to its zero position (the reference position). To keep the springs from causing the mass to overshoot and oscillate about the reference position, some form of damping is needed. This is usually supplied by using an oil-filled case with vanes for oil to bypass the mass.

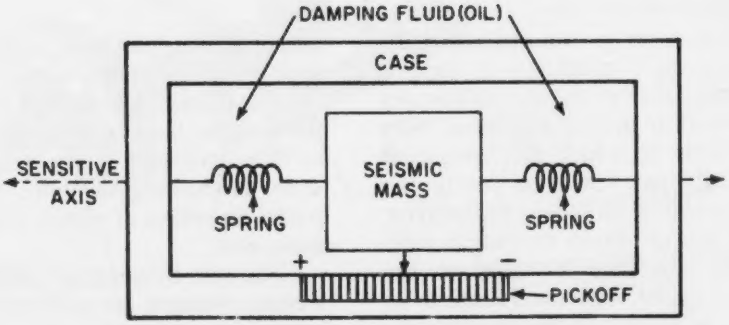

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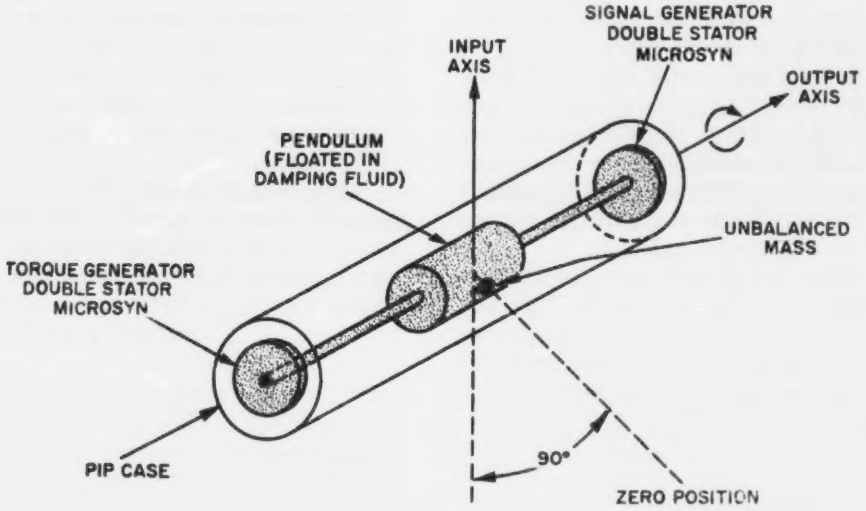
Figure 2-19.—The basic accelerometer.

An accelerometer is sensitive to gravity when its sending axis is positioned so that gravity can move or attempt to move the seismic mass. This is useful in that we can use gravity as a reference for testing purposes, but it can be a serious problem because of the errors it may cause in acceleration measurements. If the unit is placed with the sensing axis vertical, the mass will be displaced so that the output is 1 G, or 1 gravity. This is done during testing, then when the sensitive axis is turned so that it is horizontal to the earth, the springs center the mass, and the output of the unit is zero.

PULSE INTEGRATING PENDULOUS ACCELEROMETER (PIPA)

The pulse integrating pendulous accelerometer (PIPA) is used in FBM guidance systems to measure the missile's acceleration. A functional diagram of this unit is shown in figure 2-20. Basically, the unit consists of a metal cylinder enclosing a smaller metal cylinder, which contains an unbalanced mass (pendulum) suspended in a viscous damping fluid. Two microsyns are located on the output (longitudinal) axis of the pendulum cylinder. One of the microsyns serves as a torque generator and the other as a signal generator. The two microsyns are of the double stator type (ducosyn) which also provide magnetic suspension for the pendulum cylinder. The temperature of each PIPA is maintained at 130°F by temperature control circuitry in the environmental control subsystem. As a result, the viscosity of the fluid remains constant. Because the viscous fluid acts as a restraining force to the rotation of the float and is maintained at a constant viscosity through temperature control, the float will rotate at a known rate for a given amount of force exerted along the PIPA input axis. The signal generator is a microsyn whose stator winding is excited by a 9600-Hz signal. With acceleration exerted along a PIPA input axis, force proportional to that acceleration acts on the pendulous mass, causing a float rotation about the PIPA output axis proportional to that acceleration. This float rotation displaces the signal generator rotor with respect to the stator and generates a 9600-Hz output signal whose amplitude represents the amount of acceleration and whose phase, with respect to the signal generator excitation reference voltage, represents the direction of acceleration (positive or negative). The angular displacement of the float and the resulting output accumulated


SIGNAL GENERATOR DOUBLE STATOR MICROSYN
INPUT AXIS
OUTPUT AXIS
PENDULUM (FLOATED IN DAMPING FLUID)
UNBALANCED MASS
TORQUE GENERATOR DOUBLE STATOR MICROSYN
PIP CASE
90°
ZERO POSITION

33.320

Figure 2-20.—PIPA functional diagram.

over a time interval is proportional to the change in the velocity of the missile over the same time interval.

The PIPA signal generator output signal is conditioned then amplified and applied to a gate. When the amplitude of the PIPA output signal has attained the electronic threshold level established by the gate in either the positive or negative direction, then the PIPA is said to have experienced one velocity change increment.

An accelerometer output pulse results when the PIPA float has rotated off null in excess of threshold in either the positive or negative direction. For every pulse generated, current generated by the torque logic is applied to the PIPA torque generator to rotate the PIPA float back toward its null position. This allows pendulum movement (necessary to sense acceleration) and yet maintains the PIPA's input axis relative to the PIPA's case and, of course, stable member. This allows the guidance system (GS) to assume it's always sensing along the same axis. Torque current, controlled by the torque logic, is precise in magnitude and is applied to the PIPA torque generator for known periods of time. Torque current magnitude for each PIPA is established through component testing and empirical selection of the scale factor resistor (SFR) that is in the torquing current return circuit.

Torque current is generated continuously and is merely switched between the torque generator and the dummy load on the PIPA.

Because torque represents an acceleration experienced by the PIPA, the torque current and duration must be extremely precise; inaccuracies in torquing would cause inaccuracies in acceleration measured. The duration of torque is precisely controlled. The amplitude of the torque current is regulated by a feedback network.

At this point you should have a thorough understanding of inertial devices. In this and subsequent chapters of this training manual, we discuss the application of inertial devices to the guidance system and to the overall FBM weapon system operation.

GUIDANCE ORIENTATION

Figure 2-21 shows how the GS fits into the weapon system. Interface between the FCS and GS will be discussed later and missile interface will be covered in chapter 3.

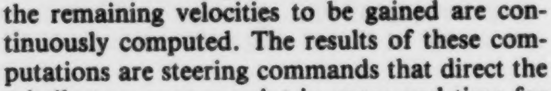
As a technician working with the GS, it will be necessary for you to have a thorough understanding of the GS. The following are specific points that will be covered.

First, we will look at how guidance works. We will also discuss the makeup of the stable platform and gimbal assembly. Further, the reference coordinate system used by guidance will be explained. All of this will then be put together to orient and stabilize the platform. Finally, the components that make up the guidance system and the policies that are applied in maintaining the system will be discussed.

HOW POSEIDON GUIDANCE WORKS

The Mk 3 guidance system must be able to guide the missile from the launch point to a point in space from which the RB will free-fall to the target. To accomplish this, the fire control system computes prelaunch current missile location and future (at time of impact) target location and inputs these to the guidance system along with time of flight. In flight, the guidance system accurately measures time and velocity gained. From these and the prelaunch fire control inputs, the remaining velocities to be gained are continuously computed. The results of these computations are steering commands that direct the missile to a proper point in space and time for RB release.

Guidance must also provide the missile with attitude reference in roll, pitch, and yaw. These attitude angles will be used to convert the steering commands from the computational coordinate system to the missile body coordinate



177.144
Figure 2-21.—Weapon system/guidance system, basic block diagram.

system as explained later in this chapter. Now let's look at how this is done.

Current missile velocity (Vm) is measured continuously by counting the total accelerometer pulses accumulated in flight at any point in time. Time expired is measured by means of a precision internal clock. By integrating velocity across the time expired, current missile location is calculated. Time remaining is calculated by subtracting time expired from the fire control input time of flight.

Every 0.64 seconds the guidance system computes a velocity value called a correlated velocity (Vc). Correlated velocity is that value of velocity that would ballistically (if thrust was terminated) get the missile from its current location to the future target location in the time remaining. By subtracting the current missile velocity (Vm) from the correlated velocity, the guidance computer determines the remaining velocity-to-be-gained (Vg). The formula Vg = Vc − Vm is used to detemine thrust termination. When Vg = 0, then Vm = Vc and the velocity needed to carry the payload ballistically to the target has been reached. This is the point where thrust is terminated. All missile steering commands are generated to drive Vg to 0.

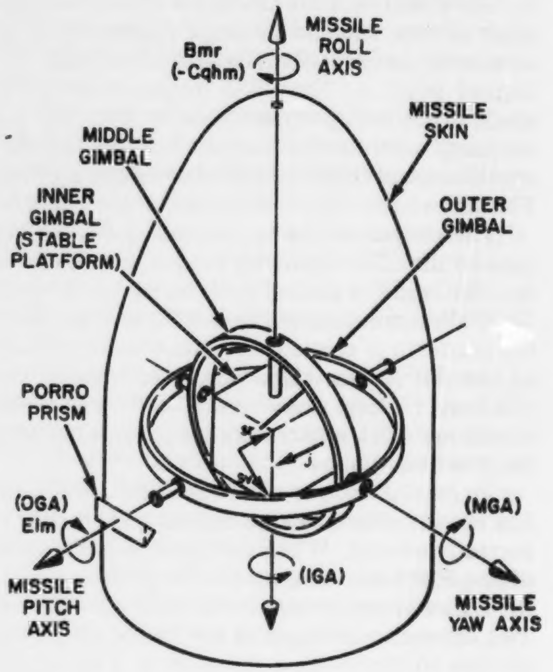
The stable platform of the guidance system remains pointed at a fixed point in inertial space throughout the missile's flight and is unaffected by any turns or maneuvers the missile makes. Because of this stable condition the missile's roll (Zvm), pitch (Eim) and yaw (Cqhm) angles can be measured. This is done with the resolvers. Since the velocity measurements and calculations take place in stable coordinates and missile steering must be done in missile body coordinates, the steering commands must be translated through these missile angles prior to use.

THE STABLE PLATFORM

An inertially guided missile requires a prescribed theoretical flight path to the target and the internal means of measuring the characteristics of its actual flight path. To correlate the prescribed missile flight characteristics with those of the actual flight, common units of measure and a common coordinate system (reference frame) are required. The common unit of measure is the change in velocity measured along the three axes of the coordinate system.

An element called the stable platform (fig. 2-22), fully stabilized about the three axes of the coordinate system and isolated from both ship and missile angular motions, is the heart of the inertial guidance system. The missile stable platform axes are aligned to the launch sector bearing, the local horizontal, and the local vertical. This stable platform provides the means to measure velocity gained along the axes of the coordinate system as previously stated.

Based on this information, it can be said that a stable platform is an inertial device that has the means to measure velocity gained (accelerometers)



NOTE:
ROLL AND YAW ANGLES ARE THE SAME AS IG AND MG ANGLES ONLY AT AN OG ANGLE OF 0 DEGREES.
OGA=OUTER GIMBAL AXIS
MGA=MIDDLE GIMBAL AXIS
IGA=INNER GIMBAL AXIS

177.145

Figure 2-22.—POSEIDON gimbal assembly.

and angles (resolvers), and the ability to remain stable (gyros).

Orienting the Platform

In chapter 1 you learned that there are three FC subsystems that are used to orient the platform: CSSS, ALNSS, and ESS. All three subsystems will be covered in more detail later in this RTM. For now, we will simply review these subsystems and see what they can do for the platform.

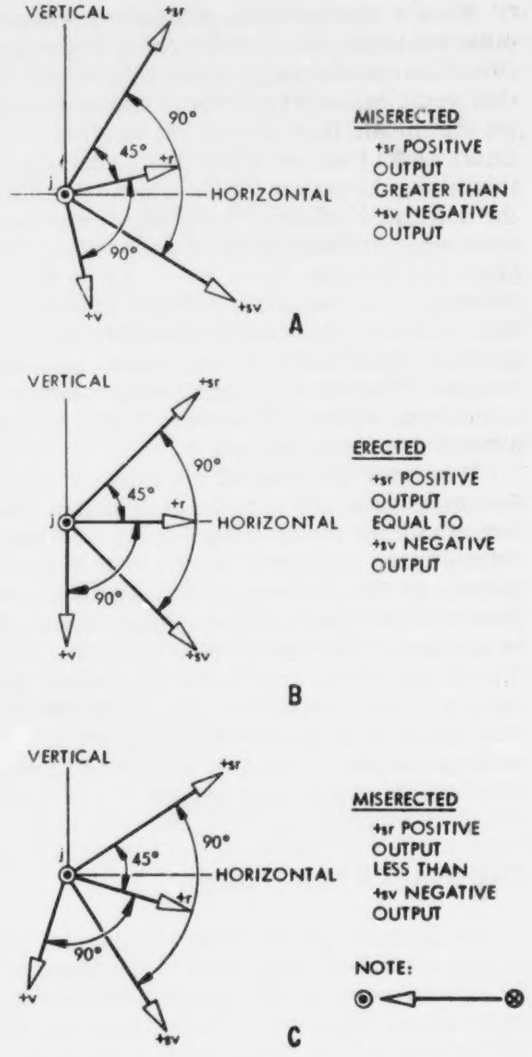
The CSSS is used to rapidly position the platform to the approximate local vertical and launch bearing. This is done so that we can reduce the total time of erection and alignment. These two subsystems, erection and alignment, are very slow compared to command slew.

The CSSS uses the OG angle (Eim), the MG angle (Zvm), and the IG angle (Cqhm/Bmr) to slew each gimbal to its approximate erected and aligned position. The CSSS outputs bypass the gimbal positioning servo loops by applying the torquing commands directly to the torquer amplifiers and then to the gimbal torque motors. This allows a much faster slewing of the gimbals.

The output of the sr, sv, and j PIPAs are used by the ESS to generate torque commands to the IRIGs in the gimbal positioning servo loop. The PIPAs are mounted on the IG so that, when the platform is erected, the input sensitive axes of the PIPAs are slant range (45° above the platform r axis), slant vertical (45° below the platform r axis), and crossrange (coincident with the platform j axis).

Figure 2-23 shows what the PIPAs will look like in two miserected conditions and when it is correctly erected. When the input sensitive axes of the PIPA are as shown in A of figure 2-23, the ESS will receive more + sr than − sv pulses. This will cause an output of the ESS to torque the gimbals to the position shown in B. This occurs because the ESS algebraically adds the output of the sr PIPA and the sv PIPA together. The resulting output will be applied to the j IRIG, which will produce an output to the gimbal torque motors. When the three PIPAs reach the positions shown in B, the sr and sv PIPAs will be producing an equal number of pulses, but of opposite polarity and the j PIPA will have no output. At this time, the GA is erected to the local vertical. The ESS will maintain this position until the platform is disconnected from FC, just prior to launch.

The alignment process positions the platform until the r axis is aligned to the sector bearing. The inner gimbal resolver signal, Bmr, is sent to FC where it is combined with ownship heading and sector bearing. The resultant alignment


VERTICAL
+sr
90°
45°
+r
j
HORIZONTAL
90°
+v
+sv
A
MISERECTED
+sr POSITIVE OUTPUT GREATER THAN +sv NEGATIVE OUTPUT
VERTICAL
+sr
90°
45°
+r
j
HORIZONTAL
90°
+v
+sv
B
ERECTED
+sr POSITIVE OUTPUT EQUAL TO +sv NEGATIVE OUTPUT
VERTICAL
+sr
90°
45°
j
HORIZONTAL
+r
90°
+v
+sv
C
MISERECTED
+sr POSITIVE OUTPUT LESS THAN +sv NEGATIVE OUTPUT
NOTE:
⊙◁——⊗

177.146

Figure 2-23.—PIPA output vs stable platform orientation.

torquing signal is routed to the gimbal servo loop to torque the inner gimbal to the sector bearing.

These three subsystems and the gimbal servo loop will be discussed in more detail later.

Gimbal Servo Loops

You have seen how FC aligns the r axis to the sector bearing and erects the v axis to the local vertical. Now, what maintains this orientation during missile flight? The answer to that question is the gimbal servo loops.

Gimbal servo loops maintain the stability of the stable platform. Angular disturbances experienced about the input axes of the IRIGs result in IRIG commands through appropriate servo loops to torque motors mounted on the gimbal shafts. The torque motors counteract the disturbing inputs to the IRIGs in self-nulling loops. The result is an unchanged orientation of the inner gimbal in inertial space or a nonrotating stable platform.

All three reference systems are used in the stabilization loops of the stable platform. IRIG outputs, measured relative to the computing coordinate axes, are converted to error signals, measured relative to the guidance reference axes. The guidance reference axes error signals are converted to gimbal error signals (gimbal axes oriented) before becoming the torquing signals that actually torque the gimbal motors.

Conversion is necessary because the IRIGs sense angular motion in the computing coordinate system, while the gimbal torque motors are located in the gimbal coordinate system. The conversion is done in the electronics and wiring of the inertial reference subsystem.

THE MK 3 GUIDANCE SYSTEM

Having discussed the concepts upon which guided missile flight is based, let us now look at the Mk 3 guidance system. This section will provide you with an overall system description, and a general functional description of each subsystem of the GS.

SYSTEM DESCRIPTION

As you can see in figure 2-24, the GS consists of seven functional subsystems. The seven functional subsystems are inertial reference, acceleration measurement, resolver, computer, timing, power supply, and environment control.

The inertial reference subsystem provides a stable platform for the inertial components of the acceleration measurement subsystem. It also provides an attitude reference for the resolver subsystem.

The acceleration measurement subsystem measures changes in missile velocity in terms of the components of velocity along the slant range (sr), slant vertical (sv), and crossrange (j) axes. Actually, in flight, the accelerometer outputs are quantized time-integrals of the nongravitational accelerations of the missile. The computer adds the effects of gravity to obtain the true missile acceleration.

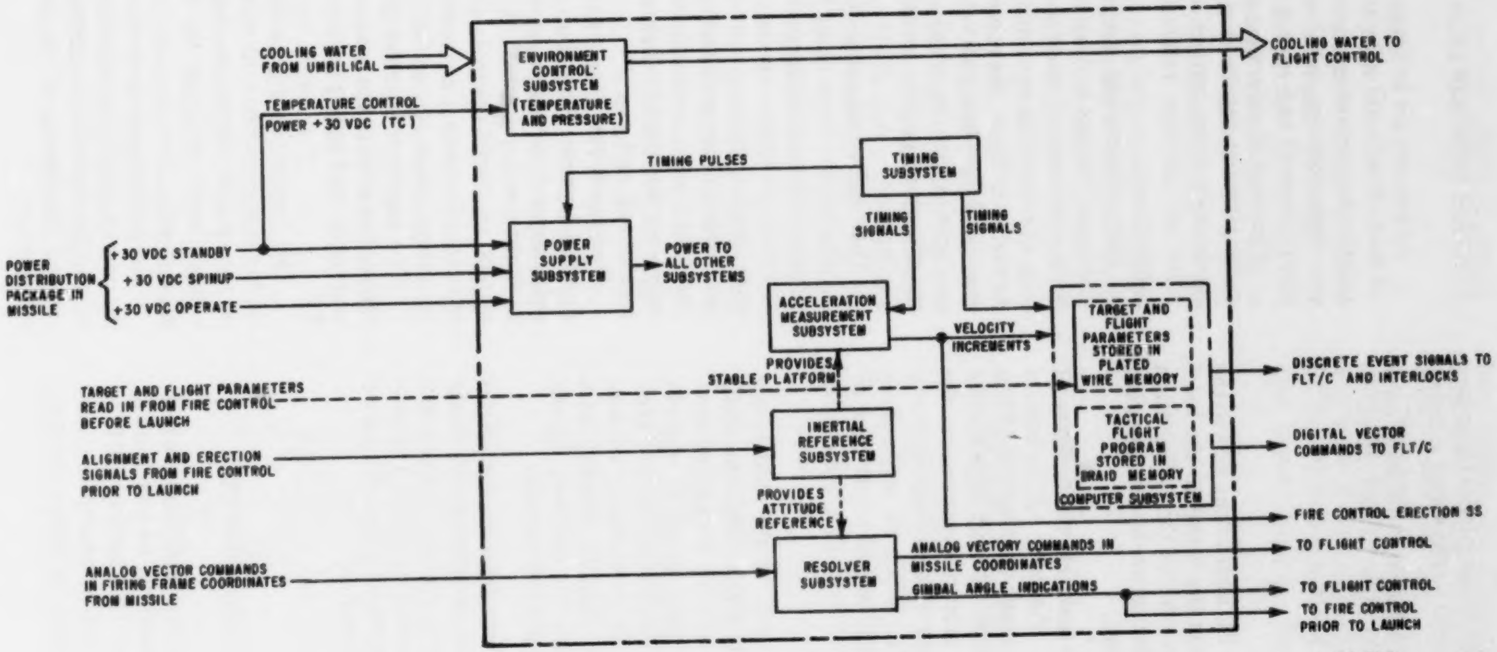
The resolver subsystem provides a coordinate transformation from firing frame coordinates to missile coordinates for the missile-commanded-direction-in-space vector (P) and for the commanded-direction-of-force vector (F). Gimbal angles are provided to the FCS for testing, command slew, and alignment. These gimbal angles are also used by flight control in controlling missile roll and yaw.

Prelaunch data from FC is stored in the computer subsystem. This data is used to solve the guidance and navigation equations. This provides in-flight steering commands and discrete control signals to flight control, electrical, and other missile subsystems, to control or indicate the operating status of the GS.

The timing subsystem provides timing and reference signals to the acceleration measurement, computer, and power supply subsystems, and to FC.

The power supply subsystem uses these timing signals with +30 volts dc, from TMPS or the missile battery, to make up the various voltage levels required by the other guidance subsystems.

The environment control subsystem maintains the proper operating temperatures and pressures for the EA and GA. In addition, it provides for external monitoring of the inertial components temperature.


COOLING WATER FROM UMBILICAL
TEMPERATURE CONTROL
POWER +30 VDC (TC)
ENVIRONMENT CONTROL SUBSYSTEM (TEMPERATURE AND PRESSURE)
COOLING WATER TO FLIGHT CONTROL
TIMING PULSES
TIMING SUBSYSTEM
TIMING SIGNALS
TIMING SIGNALS
POWER DISTRIBUTION PACKAGE IN MISSILE
+30 VDC STANDBY
+30 VDC SPINUP
+30 VDC OPERATE
POWER SUPPLY SUBSYSTEM
POWER TO ALL OTHER SUBSYSTEMS
ACCELERATION MEASUREMENT SUBSYSTEM
VELOCITY INCREMENTS
TARGET AND FLIGHT PARAMETERS STORED IN PLATED WIRE MEMORY
TACTICAL FLIGHT PROGRAM STORED IN BRAID MEMORY
COMPUTER SUBSYSTEM
DISCRETE EVENT SIGNALS TO FLT/C AND INTERLOCKS
DIGITAL VECTOR COMMANDS TO FLT/C
PROVIDES STABLE PLATFORM
TARGET AND FLIGHT PARAMETERS READ IN FROM FIRE CONTROL BEFORE LAUNCH
INERTIAL REFERENCE SUBSYSTEM
ALIGNMENT AND ERECTION SIGNALS FROM FIRE CONTROL PRIOR TO LAUNCH
PROVIDES ATTITUDE REFERENCE
FIRE CONTROL ERECTION SS
ANALOG VECTOR COMMANDS IN FIRING FRAME COORDINATES FROM MISSILE
RESOLVER SUBSYSTEM
ANALOG VECTORY COMMANDS IN MISSILE COORDINATES
TO FLIGHT CONTROL
GIMBAL ANGLE INDICATIONS
TO FLIGHT CONTROL
TO FIRE CONTROL PRIOR TO LAUNCH

173.532

Figure 2-24.—Guidance system block diagram.

INERTIAL REFERENCE SUBSYSTEM

The inertial reference subsystem provides a nonrotating attitude reference (stable platform) during flight. Inertial attitude stability during and after launch is maintained by the gyro-controlled gimbals. The stable platform provides the mounting platform for the accelerometers, whose sensitive axes lie along the sr, j, and sv computing axes. In addition, the stable platform provides a reference for missile attitude definition. Orientation of the stable member is completed before launch by the FCS.

The inertial reference subsystem includes three stabilization loops, which consist of three Mk 45 Mod 3 inertial reference integrating gyros (IRIGs), gyro output amplifiers (GOAs), a gyro error resolver, servo electronics, three gimbals, and torque motors and tachometers mounted on the gimbal shafts.

A functional part of the inertial reference subsystem is the in-flight safety (IFS) circuit, which monitors the error signals in the stabilization loops. The output of the GOAs is buffered and monitored by IFS circuitry for loss of inertial reference. The IFS circuit generates an in-flight safety inhibit computer (IFSIC) signal and sends it to the computer, if the gyro error signals exceed certain thresholds for a specified length of time, or if the 9600-Hz reference signal is lost.

Gimbal Servo Loop Operation

The self-nulling servo loop of each gimbal demodulates the IRIG error signal to a variable dc. Then, it is amplified through a torque drive amplifier, where it is applied to the gimbal torquer motor. To understand how the three servo loops maintain the stable platform as an inertial device, look at the missile during flight as it pitches over toward the target.

As the missile is being steered downrange, the entire missile turns in space, except for the tiny IRIG flywheel floats. These floats retain their inertial orientation. IRIG error signals are generated because the floats remain inertial and the missile turns. Each error signal is used to offset the input disturbance by causing the gimbal torquer motor to keep the stable platform in its original orientation. This repositioning of the stable platform will cause the IRIG error signal to be reduced to zero, and the PIPA input axes will be pointing in the same direction as they were at launch.

The events described in the preceding paragraphs take place almost instantaneously and in a continuous manner, not step-by-step as you might assume. Also, the magnitudes of displacements and the time delays between sensed error and torquing response are so minute that they are almost nonexistent from a practical standpoint.

ACCELERATION MEASUREMENT SUBSYSTEM

The acceleration measurement subsystem provides acceleration information in the form of incremental velocity pulses to the guidance computer, the FCS, and test equipment such as the Mk 492 guidance test set. The guidance computer will use this information to calculate missile position and velocity during flight. The FCS and Mk 492 will use the information to erect the stable platform to specific orientations and to furnish gyro, PIPA, and alignment and erection data during GA testing.

The acceleration measurement subsystem consists of three pulsed integrating pendulum accelerometers (PIPAs), a PIPA power supply, a PIP power supply regulator, a serial coder, and a PIPA isolation module. Each PIPA includes a permanent magnet pulsed integrating pendulum (PIP), an ac calibration module, and a PIPA electronics module. The PIPAs and the PIPA power supply are mounted on the stable platform, the PIP power supply regulator and PIPA isolation module are on the case mounted electronics (CME), and the serial coder is located in the electronics assembly (EA).

PIP

The PIP, the sensing element of the acceleration measurement subsystem, consists of three basic elements: a pendulum (float assembly), a signal generator, and a torque generator. Acceleration along the input axis of the PIP will cause the pendulum mass to be torqued from the null position. The signal generator will produce an error signal that has a phase and amplitude indicative of the direction and the amount of deflection of the pendulum mass from the null position.

The signal generator is interrogated at a 4800-pps rate by the PIPA electronics. When the error signal exceeds a predetermined threshold level, a torquing current pulse will be sent to the torque generator. This pulse restores the pendulum to null. The PIPA uses ternary torquing. That is, a torque current pulse is applied in one of two directions, or no torque is applied if the acceleration input is zero or if the float position is less than the threshold at interrogation time. The torquing current is always of constant magnitude (equivalent to 19.3 g of restoring torque). When required, it is applied for 196 microseconds in the normal mode and for 49 microseconds in the vernier mode of GS operation.

Serial Coder

The serial coder will receive a positive or negative incremental velocity bit from the interrogator whenever the PIP error signal exceeds the interrogator's threshold level. Each velocity bit corresponds to a velocity change of approximately 0.132 fps^2 in the normal mode, and approximately 0.033 fps^2 in the vernier mode. Because the interrogator is controlled by a 4800-pps signal, it can generate anywhere from 0 to 4800 bits per second. In the normal mode, the maximum velocity change that can be measured by the PIPA is approximately

$$(4800)(0.132) = 633 \text{ fps}^2 = 19.7\text{g}$$

In the vernier mode the PIPA can measure approximately

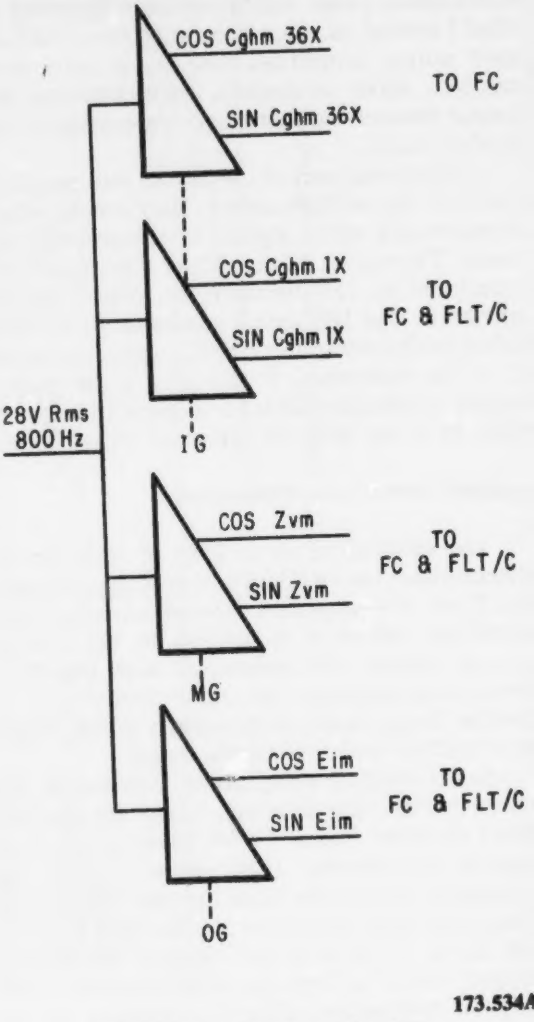
$$(4800)(0.033) = 158.4 \text{ fps}^2 = 5\text{g}$$

If the PIP is subjected to an acceleration of 1g (in the normal mode), the interrogator will see the error signal exceeding the threshold level 244 times per second.

$$\frac{1_g}{.132} = \#\text{ of bits } (1\text{g} = 32.17 \text{ fps}^2)$$

$$\frac{32.17}{.132} = 244$$

The incremental velocity pulses, ± i(Um)s, generated by the PIPA electronics, are independently coupled by transformers in the PIPA isolation module to the serial coder. The serial coder will process these pulses and gate them out to either the FCS or the guidance computer, depending on the timing signals received from the timing reference generator section of the timing subsystem. The serial coder will also generate a delta time (DT) interrupt signal to the computer to update the time count in the plated wire memory.



173.534A

Figure 2-25.—Resolver subsystem.

RESOLVER SUBSYSTEM

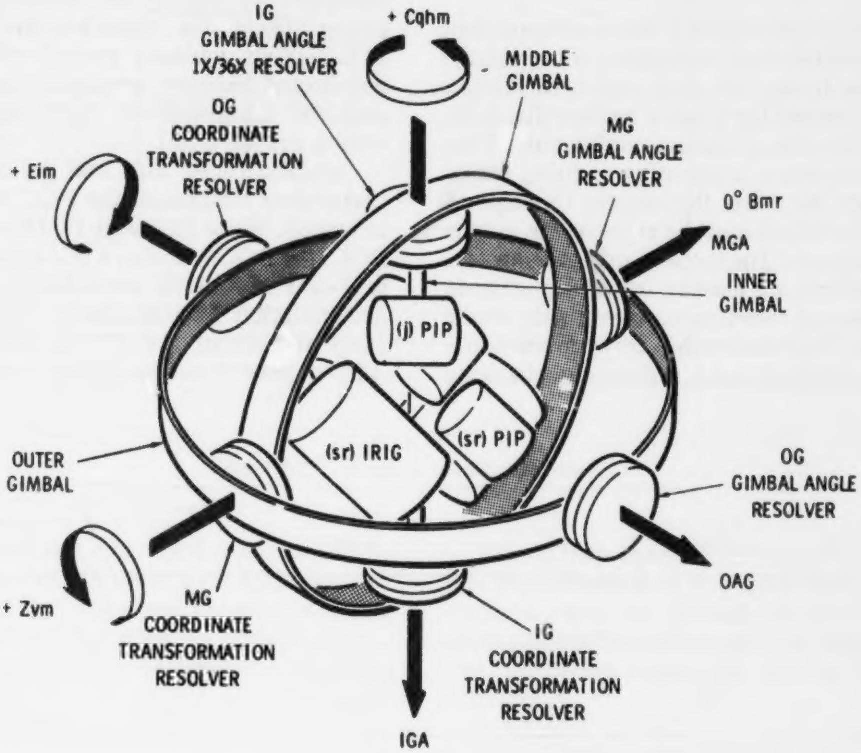
The resolver subsystem (fig. 2-25) provides FC with gimbal angles that are used to develop command slew and alignment torquing commands before launch. During missile flight the resolver subsystem provides missile roll to the flight control subsystem (flt/c). The resolver subsystem also transfers the P and F vectors to the flight control subsystem, at the same time transforming these vectors from the firing frame to the missile frame.

Gimbal Angle Resolvers

Three gimbal angle resolvers (fig. 2-26) are used to measure the angular relationship between the gimbals. The inner, middle, and outer gimbal resolvers describe the angle between the inner and middle (Cqhm/Bmr) gimbal, middle and outer (Zvm) gimbal, and outer gimbal and missile frame (Eim), respectively. The three resolvers are one-speed (1X) resolvers. However, the Cqhm resolver has a second winding (36X) used to generate a fine positioning signal.

The three 1X signals are used by FC to produce command slew signals. The 1X inner gimbal resolver is also used to generate torquing signals to coarse align the inner gimbal. At the completion of coarse align, the 36X signal is used to fine align the inner gimbal.

Flt/c exercises roll control over the missile to prevent the middle gimbal from going into the stops (approximately ±70°), in which case the missile would become unstable. The roll-command signal (sin Zvm) and the roll-polarity signal (sin Eim) are used to provide roll control. For roll angles of less than ±14.8°, there


IG
GIMBAL ANGLE
1X/36X RESOLVER
+ Cqhm
MIDDLE
GIMBAL
OG
COORDINATE
TRANSFORMATION
RESOLVER
MG
GIMBAL ANGLE
RESOLVER
+ Eim
0° Bmr
MGA
INNER
GIMBAL
(j) PIP
(sr) IRIG
(sr) PIP
OUTER
GIMBAL
OG
GIMBAL ANGLE
RESOLVER
OAG
+ Zvm
MG
COORDINATE
TRANSFORMATION
RESOLVER
IG
COORDINATE
TRANSFORMATION
RESOLVER
IGA

173.535

Figure 2-26.—Mk 3 GA axes and components.

is no output correction from flt/c. At Zvm angles between + 14.8° and + 19° and between − 14.8° and − 19°, the output is linear and proportional to the Zvm angle. Above ± 19° a maximum roll-command signal is produced.

P and F Vectors

P and F vector words are transmitted by the POSEIDON guidance computer (PGC) as 34-bit digital words. As you can see in figure 2-27, each digital word is made up of three 10-bit data words (Pxg, Pyg, and Pzg or Fxg, Fyg, and Fzg), three sign bits, and a mode bit. P vectors are used throughout the powered flight of the missile to steer the missile to the point of thrust termination. F vectors are issued only during equipment section flight and are used to command the direction and magnitude of applied thrust.

P and F Vector Conversion

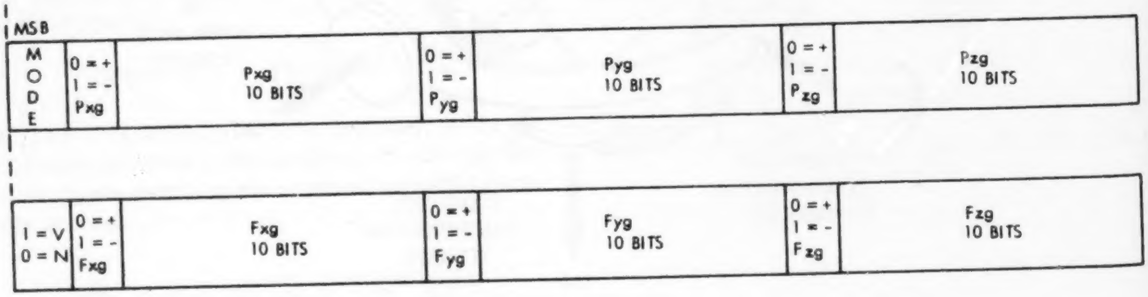
Before flt/c can use the P and F vectors, they must be converted to an equivalent analog voltage in the missile frame. The D/A converter section of flt/c will convert the P and F vectors (fig. 2-28) into an analog voltage and accomplish part of the axes transformation (computing to firing frame coordinates). But, for the missile to respond properly, the vectors must be expressed in missile frame coordinates. The three coordinate transformation resolvers are used to transform attitude (P) and force (F) vectors to the missile frame coordinates. The relationship between the firing frame and missile frame is a dynamic, changing relationship, varying as the missile rolls, yaws, and pitches. Because of this, resolver chains are used to provide continuous mathematical equivalent of the vector commands transformed into missile coordinates.

From the GA, the transformed vector signals (− Vxm, Vym, and V2m) are sent to demodulators in flt/c. The demodulators use both an 800-Hz, 90° out-of-phase and an 800-Hz, in-phase reference signal to demodulate the vectors into three F commands and three P commands, respectively. The z and y commands are used in flt/c to produce pitch and yaw commands. The x command is used to produce pitch and yaw bias, which compensate for the angle at which the reentry bodies are mounted on the equipment section.

COMPUTER SUBSYSTEM

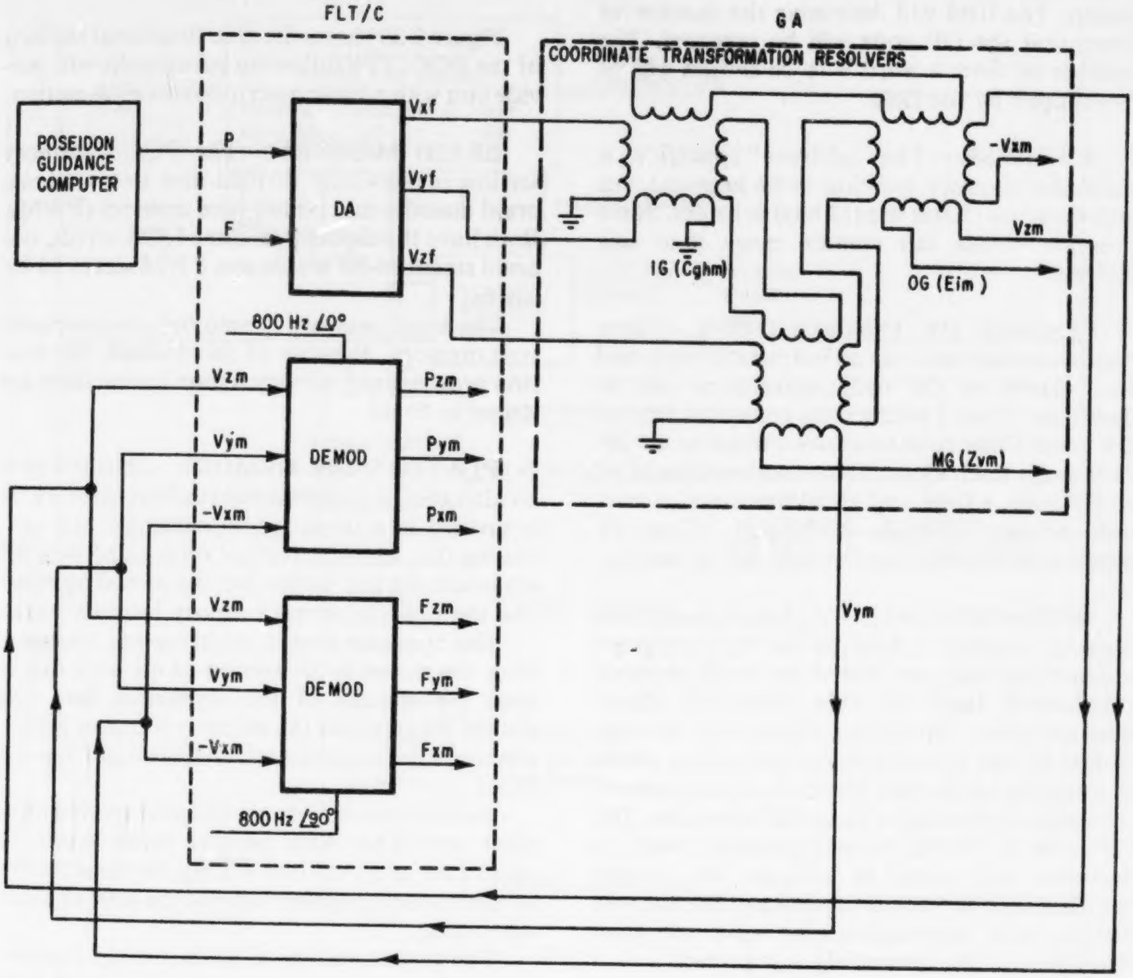
A general-purpose digital computer is employed to direct the missile through the proper flight for reentry-body release. The POSEIDON guidance computer (PGC) has a preselected mission program that is used to perform computations and make decisions during missile flight.

Specific flight data and guidance accuracy corrections are sent to the PGC from FC prior to launch. When FC issues TO (Time Zero) to the PGC, the PGC becomes a real-time computer. It is aware of missile performance through the accumulation of incremental velocity changes (Δvs) sent from the PIPAs and (starting at TO) elapsed time data (Δts) from the timing



177.147

Figure 2-27.—P and F vector digital words.


FLT/C
G A
COORDINATE TRANSFORMATION RESOLVERS
POSEIDON GUIDANCE COMPUTER
P
F
DA
Vxf
Vyf
Vzf
IG (Cghm)
-Vxm
Vzm
OG (Eim)
800 Hz ∠0°
Vzm
Vym
-Vxm
DEMOD
Pzm
Pym
Pxm
MG (Zvm)
Vym
Vzm
Vym
-Vxm
DEMOD
Fzm
Fym
Fxm
800 Hz ∠90°

173.534B

Figure 2-28.—P and F vector conversion.

subsystem. When the computer uses all of this information (prelaunch data, Δvs, Δts, and the mission program), it can direct the missile to an attitude that will enable the reentry vehicles to impact with a certain accuracy on preselected targets.

PGC Programming

Before looking at the functional sections of the PGC, let us talk about the methods used by the PGC to execute the mission program.

The microprogram instructions in the PGC repertoire conform to a specific format. The instruction words are divided into 6-bit segments called characters. Three types of characters are used: operation codes (OP codes), fields, and addresses.

OP CODES.—The OP code designates the particular instruction to be executed, such as add, subtract, or jump. OP codes are one character (6 bits) in length.

FIELD.—Fields are one character (6 bits) in length. The field will determine the number of times that the OP code will be repeated. The number of times a word is to be shifted will be determined by the field.

ADDRESS.—The address specifies a particular memory location to be accessed. An address is two characters (12 bits) in length. Some program words can contain more than one address.

CLASSES OF INSTRUCTIONS.—Three basic characters make up an instruction word, and four classes of OP code instructions can be developed. Class I instructions consist of only an OP code. Class II instructions consist of an OP code and a field. Class III instructions consist of an OP code, a field, and an address (one instruction permits multiple addresses). Class IV instructions consist of an OP code and an address.

MICROPROGRAM.—Implementation of the mission program is done by the microprogram instructions that are stored in braid memory (explained later in this chapter). Each microprogram instruction (operation) is controlled by one or more 96-bit instruction words that consist of discrete bits that direct (control) the computer through a particular operation. The OP code is fetched from a program word, is decoded, and used to address the proper microinstruction word(s) in memory. The discrete bits in each microinstruction word are then decoded and the instruction is executed.

LIST PROCESSING.—Many of the OP codes are executed using list processing. List processing is a technique that enables data, temporarily located in a memory area known as the list, to be sequentially used during instruction execution without requiring specific addressing of each data location. Operations are performed on the operands at the top of the list. The computational results of these operations replace the original data at the top of the list. Data is continually removed from the list, and new data is put in the list as the OP codes direct the computer up and down the list. List processing permits computational operations to be executed in minimal time.

PGC Functional Description

Figure 2-29 shows the nine functional sections of the PGC. The following paragraphs will provide you with a basic description of each section.

BRAID MEMORY.—The PGC's memory section is physically divided into two sections: braid memory and plated-wire memory (PWM). Both have the capacity to store 1,024 words, but braid stores 96-bit words and PWM stores 24-bit words.

The braid memory is read only nonalterable type memory. Because of this feature, the mission program and microprogram instructions are stored in braid.

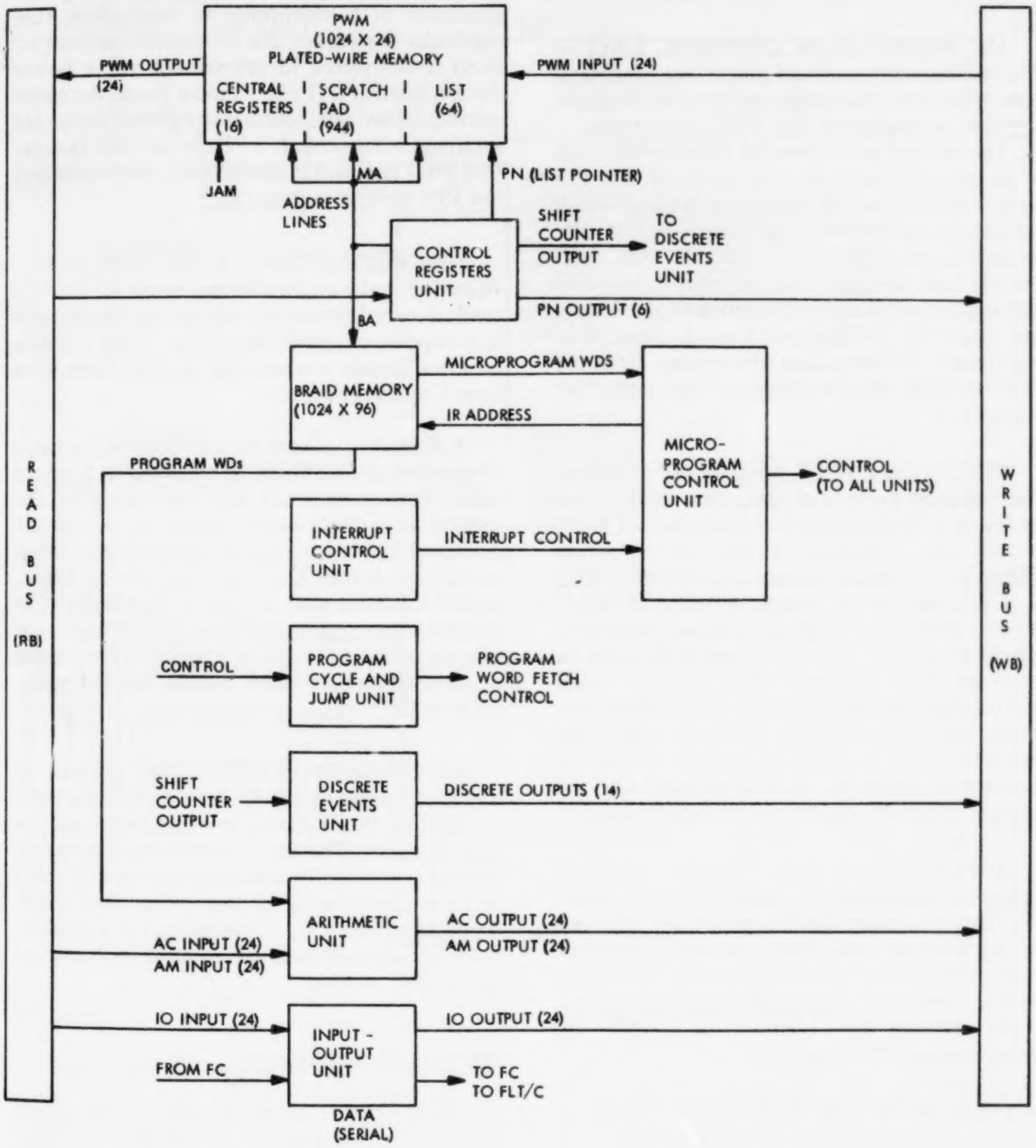
PLATED WIRE MEMORY.—The PWM is an alterable, nondestructive readout memory. It is divided into three functional areas: the processing list, which is further subdivided into the arithmetic list and output list; the central registers; and the random access memory (scratch pad).

The operands used in mathematical computations are stored in the section of memory that is used for storage of the arithmetic list. The output list serves as the memory location for the storage of information to be outputted from the PGC.

The central registers are assigned specific locations in PWM. This permits rapid access to particular data required during implementation of the mission program, without the need of direct addressing.

The scratch pad serves as the storage location for all alterable information (such as flight data and guidance error data loaded into memory before launch). It is also used as the storage location for alterable portions of the mission program, as the location for test programming, and, in general, as the temporary location for various data.

CONTROL REGISTERS UNIT.—The control registers unit performs the function of addressing braid and PWM. It will also perform address modifications, indexing, shifts, overflow monitoring, list protection, and formation of program manager words (PROMAN). PROMAN are status words that record the contents of key registers during an interrupt routine and permit


PWM
(1024 X 24)
PLATED-WIRE MEMORY
CENTRAL REGISTERS (16)
SCRATCH PAD (944)
LIST (64)
PWM OUTPUT (24)
PWM INPUT (24)
JAM
MA
ADDRESS LINES
PN (LIST POINTER)
SHIFT COUNTER OUTPUT
TO DISCRETE EVENTS UNIT
CONTROL REGISTERS UNIT
PN OUTPUT (6)
BA
BRAID MEMORY (1024 X 96)
MICROPROGRAM WDS
IR ADDRESS
MICRO-PROGRAM CONTROL UNIT
CONTROL (TO ALL UNITS)
PROGRAM WDs
READ BUS (RB)
WRITE BUS (WB)
INTERRUPT CONTROL UNIT
INTERRUPT CONTROL
CONTROL
PROGRAM CYCLE AND JUMP UNIT
PROGRAM WORD FETCH CONTROL
SHIFT COUNTER OUTPUT
DISCRETE EVENTS UNIT
DISCRETE OUTPUTS (14)
ARITHMETIC UNIT
AC INPUT (24)
AM INPUT (24)
AC OUTPUT (24)
AM OUTPUT (24)
IO INPUT (24)
IO OUTPUT (24)
FROM FC
INPUT - OUTPUT UNIT
TO FC
TO FLT/C
DATA (SERIAL)

173.536

Figure 2-29.—PGC.

the PGC to resume normal operations at the termination of the interrupt.

MICROPROGRAM CONTROL UNIT.—The microprogram control unit is that functional area of the PGC that generates the control signals required to implement the PGC instructions.

The control unit is loaded with the OP code of an instruction that is to be executed. The OP code is decoded as the address in braid at which the microprogram instruction word is located. The microprogram instructions word is then read. Decode logic then generates the appropriate control signals based on the presence of the 96 bits that comprise the instruction word. These control signals, in conjunction with timing, direct the PGC through the execution of the particular instruction.

PROGRAM CYCLE AND JUMP UNIT.—The program cycle and jump unit enables the retrieving of program words from braid or PWM. During the execution of the microprogram instruction words, a program cycle request (PCR) or a program jump request (PJR) can occur. When a particular program word has been completely executed, a new program word must be retrieved from memory. The program cycle control logic determines if a PCR is needed, and, if so, the next program word is read from memory. When a jump to another section of memory is requested, a PJR is made and the mission program resumes at the jump location.

ARITHMETIC UNIT.—The arithmetic unit consists of the addend-multiplicand (AM) register and the accumulator (AC) register. The AM and AC registers are used during the performance of mathematical and logical operations. They also serve as temporary storage locations for program words retrieved from memory, before they are transferred to PWM centrals.

INTERRUPT CONTROL UNIT.—The function of the interrupt control unit is to determine if any interrupt requests have been made, to service the request(s), and if necessary, to request additional interrupts. It also ensures that the most significant interrupt request is served first if more than one request has been made.

Interrupts are serviced in the order of their priority. If an interrupt occurs during the execution of a microprogram instruction, that particular segment of that instruction (subinstruction) is completed in full (except for a power failure interrupt) (PFI). In most cases, the entire microprogram instruction is completed before the interrupt is serviced. If a PFI occurs, the instruction being executed is immediately interrupted and the PFI routine is initiated.

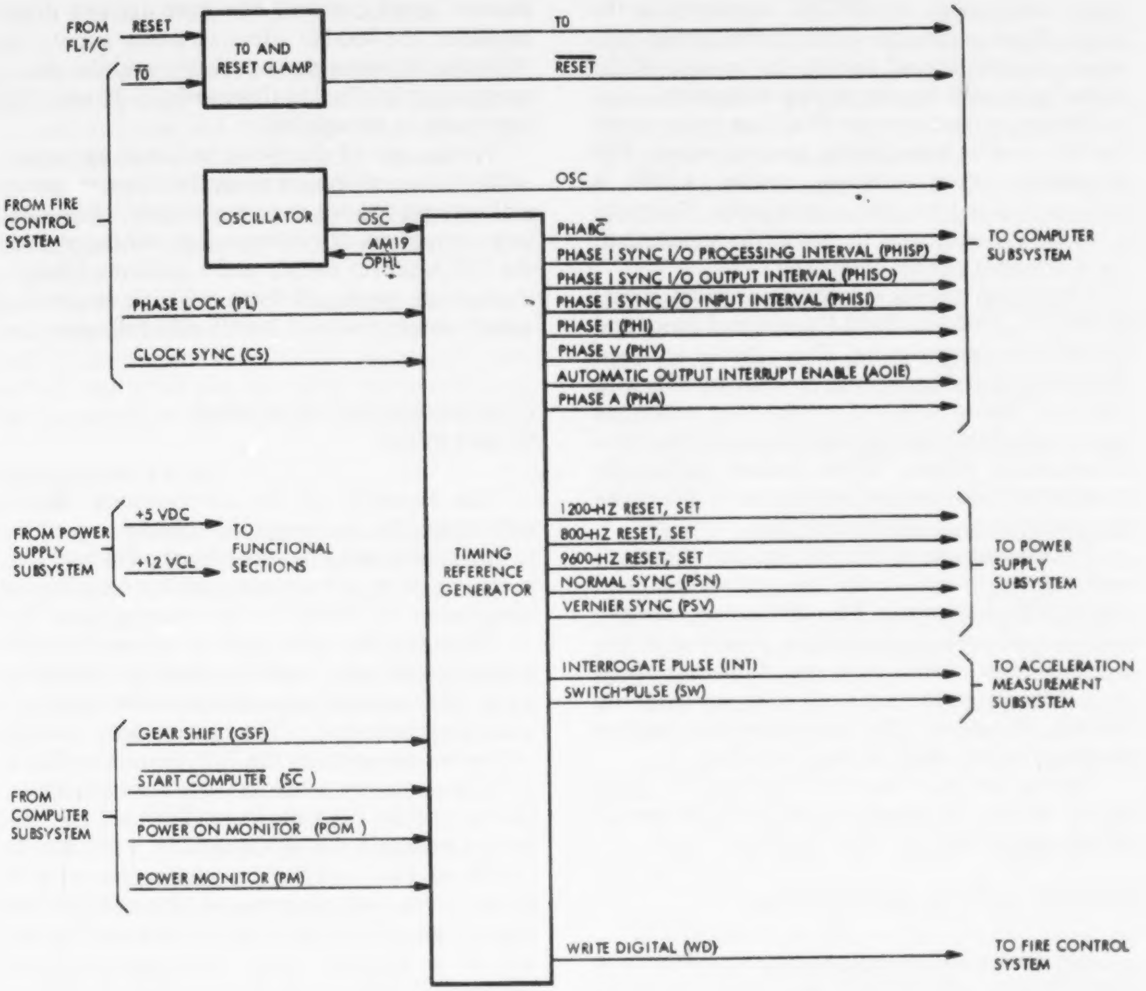
DISCRETE EVENTS UNIT.—The 10 flip-flops that make up the discrete events register are used to record certain discrete events that pertain to computer or missile operation. They will also monitor certain discrete signals that have been issued by the computer.

A discussion of each signal is beyond the scope of this manual. However, as an example, a typical signal that is recorded and monitored by the register is in-flight-safety (IFS). As previously discussed, IFS is generated by the computer, when certain conditions have occurred during flight, and IFS is then sent to missile interlocks. The discrete events register monitors IFS to ensure that it was transmitted to missile interlocks. For a more detailed discussion of the discrete events signals, refer to OP 3557.

INPUT-OUTPUT UNIT.—The purpose of the input-output unit (I/O) is to provide the communication link between the computer and the outside world. The I/O functions as a serial-to-parallel converter for data entering the PGC, and as a parallel-to-serial converter for data transferred from the PGC. It will operate as a separate piece of hardware because it has its own control and timing section.

TIMING SUBSYSTEMS

The timing subsystem provides timing signals to the PGC, power supply, acceleration measurement subsystems, and the FC system. It will also format Δvs from GA to FC on the oi(Ugm)s lines. The timing subsystem (fig. 2-30) consists of the oscillator, timing reference generator, and TO and reset clamp circuits.


FROM FLT/C
RESET
T0
T0 AND RESET CLAMP
T0
RESET
FROM FIRE CONTROL SYSTEM
OSCILLATOR
OSC
OSC
AM19
OPHL
PHASE LOCK (PL)
CLOCK SYNC (CS)
PHABC
PHASE I SYNC I/O PROCESSING INTERVAL (PHISP)
PHASE I SYNC I/O OUTPUT INTERVAL (PHISO)
PHASE I SYNC I/O INPUT INTERVAL (PHISI)
PHASE I (PHI)
PHASE V (PHV)
AUTOMATIC OUTPUT INTERRUPT ENABLE (AOIE)
PHASE A (PHA)
TO COMPUTER SUBSYSTEM
FROM POWER SUPPLY SUBSYSTEM
+5 VDC
+12 VCL
TO FUNCTIONAL SECTIONS
TIMING REFERENCE GENERATOR
1200-HZ RESET, SET
800-HZ RESET, SET
9600-HZ RESET, SET
NORMAL SYNC (PSN)
VERNIER SYNC (PSV)
TO POWER SUPPLY SUBSYSTEM
INTERROGATE PULSE (INT)
SWITCH PULSE (SW)
TO ACCELERATION MEASUREMENT SUBSYSTEM
FROM COMPUTER SUBSYSTEM
GEAR SHIFT (GSF)
START COMPUTER (SC)
POWER ON MONITOR (POM)
POWER MONITOR (PM)
WRITE DIGITAL (WD)
TO FIRE CONTROL SYSTEM

173.537

Figure 2-30.—Timing subsystem.

Oscillator

The oscillator generates a 3.9168-MHz signal (OSC and $\overline{\text{OSC}}$) that is used as the primary timing signal for the timing reference generator and for the sequencer in the PGC. The oscillator frequency is coerced to the fire control frequency by the OPHL signal, which is a product of the clock synchronization signal (CS) sent from FC to the timing reference generator.

Timing Reference Generator

The timing reference generator consists of the various logic required to develop the control and reference timing pulses that are used to synchronize the operation of the guidance system. Fire control transmits a phase lock (PL) signal to the timing subsystem that will synchronize the phase of the basic timing pulses. The other inputs to timing include start compute not ($\overline{\text{SC}}$), the gear shift (GSF), the power monitor (PM), and the power-on monitor not ($\overline{\text{POM}}$) signals from the PGC. These inputs are used in the timing subsystem as conditional signals for several of the pulses generated by the timing subsystem.

Timing outputs to the PGC are pulse trains that are used as basic timing control pulses. The automatic output interrupt enable (AOIE) is developed as an interrupt control pulse. This pulse is used in the computer to enable the servicing of the automatic output interrupt.

The power supply subsystem receives inputs of 800 Hz, 1200 Hz, 9600 Hz, normal sync, and vernier sync from timing. These pulses are used as synchronization pulses in the individual power supplies. The normal and vernier sync pulses are used in the PIPA power supply to generate synchronization pulses. These pulses enable the acceleration measurement subsystem to determine the operational mode of the GS.

Timing outputs to the acceleration measurement subsystem include the interrogate (INT) and switch (SW) pulse train. The INT pulses are used as a control pulse to enable the sampling of the accelerometer output at a specified rate (4800 pps). The SW pulses are used to direct torquing current to either the accelerometer torque windings or the dummy load winding.

The last output is the write digital (WD) signal to FC. WD is a frequency reference used during GS testing in FC.

POWER SUPPLY SUBSYSTEM

The power supply subsystem receives inputs from TMPS (+30 vdc) and the timing subsystem (800 Hz, 1200 Hz, 9600 Hz, normal, and vernier sync) and uses these inputs to provide operational power and control for the GS.

The power supply subsystem is controlled by the application of +30 vdc sequencing power from TMPS. This sequencing power (standby, spin-up, or operate) will determine which power supplies are to be turned on.

During the standby mode of operation, only +30 vdc TC (temperature control) power is applied. This will activate the temperature controllers and heaters for the accelerometers and gyros. During the spin-up mode, +30 vdc spin-up is applied. Spin-up power will activate the 1200-Hz automatic gain control (agc) and burp circuit, the 1200-Hz wheel power supplies, the case blower speed control, the case blower driver amplifier, the 800-Hz reference power supply, the 9600-Hz reference power supply, and the timing power supply. During this mode, +30 vdc (TC) continues to be applied.

At the end of the 64-second spin-up period, +30 vdc operate power is applied. Operate power will activate the servo power supply, the gimbal servo amplifiers, the computer power supply, and the PIPA power supply and regulator. Thus, in the operate mode, all three +30 vdc sequencing signals are applied and the GS is in full operation.

ENVIRONMENT CONTROL SUBSYSTEM

The function of the environment control subsystem is to maintain proper operating temperatures and pressures for the EA and GA. It also provides the temperature for each inertial component to TMPS for monitoring.

There are two basic parts to the environment control subsystem: a cooling loop and a heating loop. The cooling loop consists of blowers and a cooling water loop. The heating loop consists of heaters mounted on the PIPAs and the IRIGs.

In the standby mode, cooling water maintains the cases of the EA and GA at 62.5° ±2.5°F. The heaters maintain the IRIGs at 135° ±6°F and the PIPAs at 135° ±3°F. But, during the operate mode, extra heat is generated. Two blowers are used to remove this extra heat. One is used to draw air, at a constant flow, through the stable member. The second blower circulates air through the GA case. As launch water flow ceases, the mass of the GA provides a sufficient heat sink during the relatively short flight.

Pressure control is also important in maintaining the required environment of the GS. This avoids pressure stresses on the covers and enables proper functioning of the blowers. The EA uses two types of relief valves: a low pressure relief and two high-flow rate relief valves. These valves keep the differential pressure between the inside of the EA and the atmosphere at a minimum. The GA has one relief valve that is used to capture 1 atmosphere of pressure after launch to enable proper functioning of the blowers. Above 1 atmosphere, the valve allows a free flow of air into or out of the GA.

MK 3 GUIDANCE MAINTENANCE

Now that you have seen what is inside the black boxes that make up the Mk 3 guidance system, you may ask yourself, What can I, as a technician, do with the guidance system?

The answer to that question is, Not very much. However, you should have a good picture of how the equipment operates. This will help you as a technician.

This section describes what you, the technician, can do as far as the levels of maintenance, fault isolation, and GA and EA repairs are concerned, and when you can do it. It also tells what the temperature requirements are for the GS.

Maintenance Levels

Because of variations in space, equipment, and time available, four levels have been established for guidance maintenance (testing, fault isolation, and repair).

FIRST LEVEL.—First level maintenance capability is established aboard the submarine to assist in maintaining guidance systems in a state of maximum operational readiness.

Testing requirements at this level are divided into two parts: SSBN availability, where all GS equipment will be tested either in a missile or, if it is a spare assembly, on the guidance workbench; and, SSBN patrol, where only those GS that are installed in missiles are tested (at the rate of once every 14 days).

Repair at this level is normally limited to removal of and replacement of an EA, a GA, or both with an operable spare. EA repairs can be done on items, such as covers, gaskets, O rings, mounting bolts, and electronic modules. These can be replaced only at the discretion of the SSBN commanding officer and if there is only one good remaining spare EA. GAs are never repaired at this level.

EA fault isolation will be initiated when an assembly has failed. PGC diagnostics must be completed on board the submarine (even though repair is not to be initiated at this level) to provide a diagnostic printout so repair can be effected at the fourth level. Failure information is required on the Trouble and Failure Report (TFR) for all failed guidance systems returned to the tender.

SECOND LEVEL.—Second level maintenance capability has been established aboard tenders to assist in maintaining an adequate inventory of guidance systems for SSBN replenishment and to process suspect material offloaded from the submarines.

The only tests performed at the tender level are interface impedance, the temperature indication check, and a visual inspection.

GS repair at this level is very limited. For the GA, only the water connectors, fasteners, and plastic slides can be repaired. For the EA, only the external hardware can be replaced. All other assemblies are returned to the fourth level for repair.

Fault isolation of GAs at the tender is not authorized.

THIRD LEVEL.—Third level maintenance capability is established at POLARIS missile facilities (POMFs). The prime function of a POMF is to provide calibrated guidance systems and repair parts (external hardware) for tactical outloads and fleet resupply.

Tests required at this level include a visual inspection and an electrical interface test.

Authorized repairs at this level are the same as on a tender.

Fault isolation of GAs at the POMF is not authorized beyond the failure confirmation process.

FOURTH LEVEL.—The fourth level of maintenance, represented by the prime contractor factories, supports the supply facilities by providing complete manufacturing, modification, and repair capabilities.

There are no limits placed on the fourth level for testing, repair, or fault isolation.

Temperature Requirements

The guidance system temperature and humidity requirements are established to protect the GS from accuracy and reliability degradation because of temperature and/or moisture.

Humidity requirements are for an operating range of 75° ±10°F, at a humidity of 43% ±37%. The temperature requirement for the accelerometer is 135° ±3°F, and for the gyro it is 135° ±6°F.

Cooldown of a GA does not significantly degrade the accuracy or reliability of the guidance system. Therefore, no special tests are required for GAs that have cooled down because of a loss of heater power. However, the internal GA temperature must be returned to normal (no temperature alarm) prior to going into the guidance spin-up or operate modes. The time required to return to normal temperature will be approximately equal to the time without heater power up to a maximum of approximately 3 hours in an ambient temperature of 70 °F. For more information on maintenance and temperature requirements, see NAVORD OP3557, volume 2.

In summary, let us look at the GS as it fits into the FBM weapon system. The GS interfaces with the FC system to erect and align the stable platform, to read in digital flight and test information, and to monitor power, temperature, and operations. It also interfaces with the missile to provide mode control, steering commands, attitude reference, and control commands.

Additional information on the operation of the Mk 3 guidance system may be found in NAVORD OPs 3557 and 3804.

CHAPTER 3

POSEIDON FIRE CONTROL SYSTEM MK 88 MOD 1

The POSEIDON Fire Control System Mk 88 Mod 1 prepares POSEIDON missiles for sequential launching and self-guidance after launch. The preparation of the missiles consists of supplying power to operate the missile electronic circuits, positioning the missile stable platform to a desired position through alignment and erection signals, and entering guidance and fuze set data into the missile computer. Coordination of the launch sequence consists of monitoring the subsystems of the weapon system involved in the launch sequence and generating commands to initiate the sequential functions at the proper time.

GENERAL DESCRIPTION

The majority of the Fire Control System is located in the lower level operations compartment of the FBM submarine. Elements of subsystems are also located in the Attack Center and the Missile Compartment. Figure 3-1 illustrates the compartments on board an FBM where the Fire Control System is located. (It also depicts the overall layout of the ship.)

The fire control functions are accomplished in two separate sequences by 12 separate equipment subsystems. The sequences consist of missilized and channelized operations.

MISSILIZED OPERATIONS

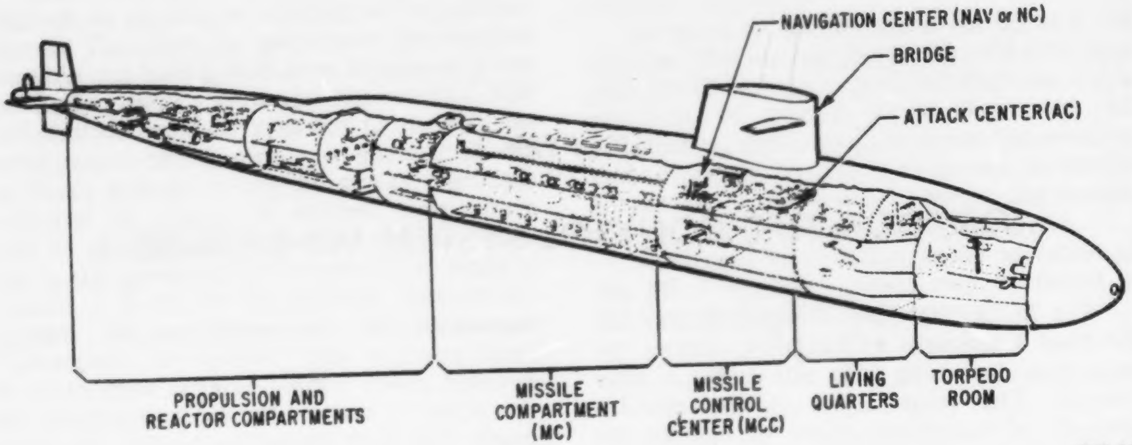
The missilized operations are time-consuming functions and require separate circuits for each missile. The missilized operations are performed on all missiles simultaneously and consist of temperature monitor power supply (TMPS) monitoring of the guidance system, the erection process and coarse alignment process to position the stable platform, and missilized digital operations performed by the digital control computer (DCC). At the completion of the missilized operations, the Fire Control System is ready to start channelized operations.

CHANNELIZED OPERATIONS

Channelized operations are initiated by a fire control operator, normally an FTB. The channelized operations require relatively short time periods and are accomplished on only two missiles at a time. These operations consist of command slew, missile battery activation and missile checkout, launcher preparations, missile number check, guidance and fuze set computations, readin of data to the missile, fine alignment, check of guidance and fuze set data, and launching of the missile.

Denote and Assign

These channelized operations are performed in two sequences, denote and assign. The denote sequence begins when all missilized operations are complete and is terminated when the missile battery is activated. The denote sequence is primarily to allow pressurization of the missile launcher tube and other launcher functions in the missile compartment. The assign sequence begins immediately after the denote sequence and terminates when the missile is launched. This sequence allows final launcher preparations of the missile and final fire control functions to


NAVIGATION CENTER (NAV or NC)
BRIDGE
ATTACK CENTER(AC)
PROPULSION AND REACTOR COMPARTMENTS
MISSILE COMPARTMENT (MC)
MISSILE CONTROL CENTER (MCC)
LIVING QUARTERS
TORPEDO ROOM

258.10

Figure 3-1.—Fleet Ballistic Missile Submarine.

be completed. The missiles are sequenced through the channelized operation in accordance with a previously selected missile-to-firing order, starting with the lowest firing order and ending with the highest firing order. Depending on the tactical situation, manual or automatic sequencing of the missiles through channelized operations may be used.

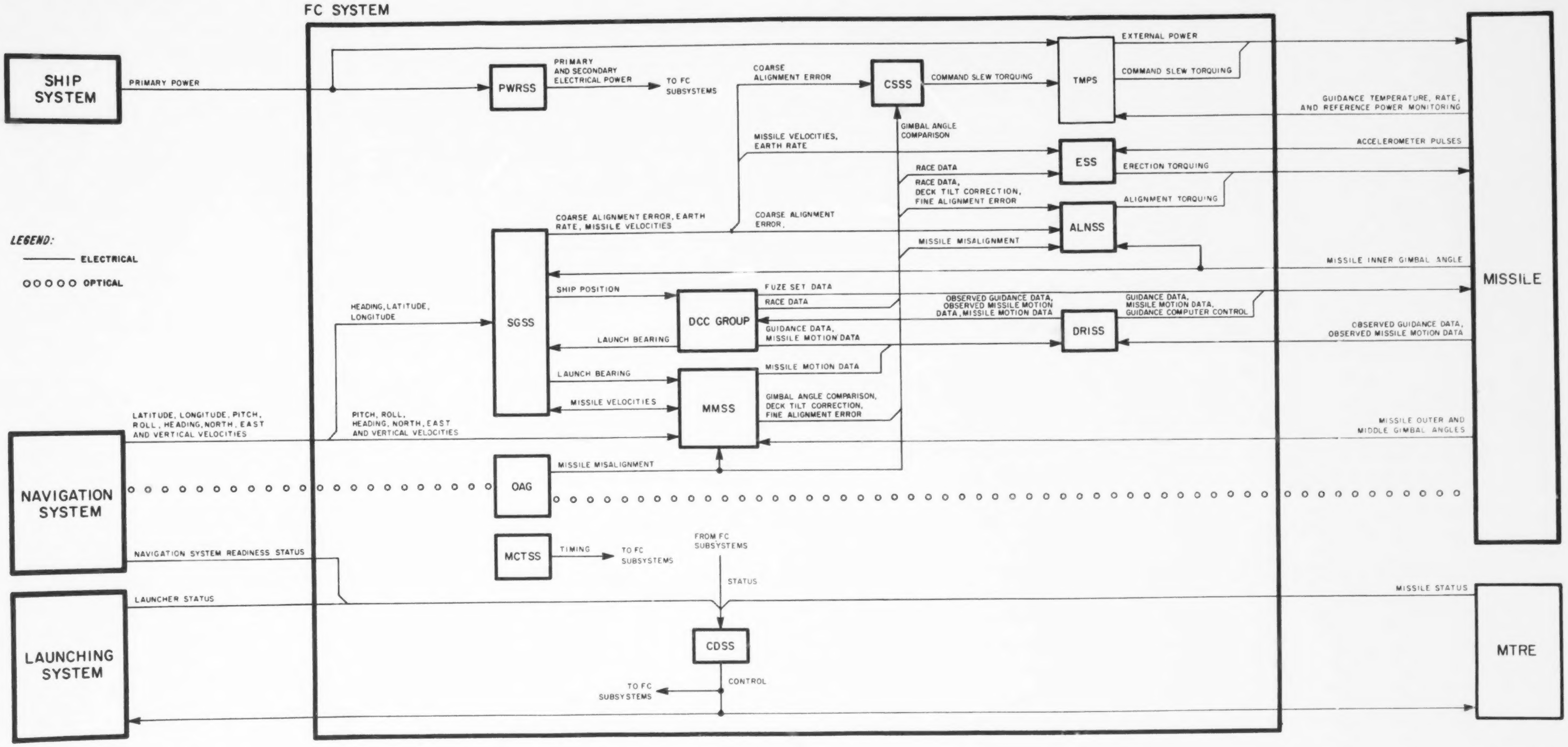
SUBSYSTEMS

The 12 equipment subsystems of the Fire Control System are the power subsystem (PWRSS), TMPS, master clock and timing subsystem (MCTSS), control and display subsystem (CDSS), command slew subsystem (CSSS), optical alignment group (OAG), alignment subsystem (ALNSS), erection subsystem (ESS), missile motion subsystem (MMSS), servo group subsystem (SGSS), DCC group, and digital readin subsystem (DRISS). The operation of each of these subsystems in conjunction with the rest of the weapon system performs the fire control operation of preparing the missile and coordinating the launch sequence. While some of the above terms and abbreviations are unfamiliar to you now, this chapter will describe their functions to make them clear. Each of the subsystems and its interface with the others will be described in the following paragraphs. Referring to figure 3-2 will greatly assist you in understanding their functions.

SUBSYSTEM FUNCTIONAL DESCRIPTION

POWER SUBSYSTEM

The power subsystem controls, monitors, and distributes primary power within the Fire Control System and provides overload protection for fire control equipment. The primary location of PWRSS is in MCC. PWRSS receives power from the ship system. This subsystem also generates and distributes secondary power required by the Fire Control System. Primary power consists of 28 V d.c. and 120 V, 400 Hz, 1-Ø and 3-Ø power. The 28 V d.c. is used for operation of motor-driven switches, relays, and indicators. The 120 V, 400 Hz, 1-Ø power provides reference excitation for resolvers and servos used in processing analog data. The 120 V, 400 Hz, 3-Ø power provides excitation for special power supplies and electromechanical devices such as fan motors, disk drive motors, tape readers and printers. Secondary power consists of 10 V d.c., 20 V d.c., 28 V d.c., and 45 V d.c., and two reference signals (400 Hz and 800 Hz). Secondary power


FC SYSTEM
SHIP SYSTEM
PRIMARY POWER
PWRSS
PRIMARY AND SECONDARY ELECTRICAL POWER
TO FC SUBSYSTEMS
COARSE ALIGNMENT ERROR
CSSS
COMMAND SLEW TORQUING
TMPS
EXTERNAL POWER
COMMAND SLEW TORQUING
GUIDANCE TEMPERATURE, RATE, AND REFERENCE POWER MONITORING
GIMBAL ANGLE COMPARISON
MISSILE VELOCITIES, EARTH RATE
ESS
ACCELEROMETER PULSES
ERECTION TORQUING
RACE DATA
RACE DATA, DECK TILT CORRECTION, FINE ALIGNMENT ERROR
ALIGNMENT TORQUING
ALNSS
COARSE ALIGNMENT ERROR, EARTH RATE, MISSILE VELOCITIES
COARSE ALIGNMENT ERROR,
MISSILE MISALIGNMENT
MISSILE INNER GIMBAL ANGLE
MISSILE
LEGEND:
ELECTRICAL
OOOOO OPTICAL
SGSS
SHIP POSITION
FUZE SET DATA
RACE DATA
DCC GROUP
OBSERVED GUIDANCE DATA, OBSERVED MISSILE MOTION DATA, MISSILE MOTION DATA
GUIDANCE DATA, MISSILE MOTION DATA, GUIDANCE COMPUTER CONTROL
HEADING, LATITUDE, LONGITUDE
LAUNCH BEARING
GUIDANCE DATA, MISSILE MOTION DATA
DRISS
OBSERVED GUIDANCE DATA, OBSERVED MISSILE MOTION DATA
MISSILE MOTION DATA
LAUNCH BEARING
MISSILE VELOCITIES
MMSS
GIMBAL ANGLE COMPARISON, DECK TILT CORRECTION, FINE ALIGNMENT ERROR
LATITUDE, LONGITUDE, PITCH, ROLL, HEADING, NORTH, EAST AND VERTICAL VELOCITIES
PITCH, ROLL, HEADING, NORTH, EAST AND VERTICAL VELOCITIES
MISSILE OUTER AND MIDDLE GIMBAL ANGLES
OAG
MISSILE MISALIGNMENT
NAVIGATION SYSTEM
MCTSS
TIMING
TO FC SUBSYSTEMS
FROM FC SUBSYSTEMS
STATUS
NAVIGATION SYSTEM READINESS STATUS
LAUNCHER STATUS
MISSILE STATUS
MTRE
LAUNCHING SYSTEM
CDSS
CONTROL
TO FC SUBSYSTEMS

173.287

Figure 3-2.—POSEIDON Fire Control System Mk 88 Mod 1 Data Flow.

provides reference signals and power for the fire control computing circuits. PWRSS consists of the power input panel (PIP) assembly, power control and protection panels (PCPP), and special power supplies.

Power Input Panel Assembly

The power input panel assembly allows us to monitor, control, fuze, and distribute primary power to the Fire Control System. The PIP assembly receives 28 V d.c., 120 V, 400 Hz, 1-0 and 3-0 power from the ship and weapon system distribution located in the ship system. The PIP assembly monitors the three inputs closely to ensure that they are well within the specified operating limits. We may observe the indications at the top of the PIP assembly.

The distribution of the 28 V d.c. and 120 V, 400 Hz, 1-0 and 3-0 power from PIP is controlled by manual and remote/manual switching circuits. The manual switching circuits distribute primary power to the circuits and equipment that operate independently of Fire Control System operational modes. The remote/manual switching circuits route primary power to the fire control subsystems and associated weapon system equipment that require power only in certain system modes. Power from the switching circuits is routed to its destination via the power control and protection panels (PCPPs).

Power Control and Protection Panels

The PCPPs distribute primary power to the post-mounted equipment in the missile control center (MCC). The PCPPs receive 28 V d.c. and 120 V, 400 Hz, 1-0 and 3-0 power from the power input panel assembly. The PCPPs monitor the power for proper level and display the condition of the power by light indications. The PCPPs also control the application of power to the fire control subsystems and special power supplies located within the posts. The fire control operator may isolate a specific power or isolate the power from the entire door post by using the switches/circuit breakers on the PCPPs. This is important when troubleshooting is done and modules are replaced.

Special Power Supplies

The special power supplies provide the power required by the Fire Control System computing circuits. The special power supplies are the d.c., 400 Hz, and 800 Hz power supplies. The d.c. power supplies use the 120 V, 400 Hz, 3-0 power from the PCPPs to generate 10 V d.c. and 20 V d.c. for the digital computing circuits and 28 V d.c. and 45 V d.c. for the analog computing circuits. The 400 Hz power supply uses 120 V, 400 Hz, 1-0 power from the PCPP to generate the 400 Hz computing reference signals used by the erection subsystem (ESS) and the missile motion subsystem (MMSS). The 800 Hz power supplies use 120 V, 400 Hz, 3-0 power from the PCPPs to generate 800 Hz reference signals used by the servo group subsystem (SGSS) and the erection subsystem (ESS).

TEMPERATURE MONITOR POWER SUPPLY MK 141 MOD 1

TMPS provides prelaunch external power to the missile until the missile is switched to internal power just prior to it being launched. TMPS also monitors the temperature of the missile guidance system inertial components and the missile reference signals from the guidance system. TMPS operates in three separate modes and uses four power supplies and several monitoring circuits to perform its functions.

The three operating modes of TMPS are standby, spinup, and operate. In the standby mode, which is manually initiated by an FTB operator at TMPS, a continuous 30 V d.c. signal is supplied to the guidance system, where it controls the internal temperature of the guidance system. During the standby mode, TMPS monitors the internal temperature of the guidance system. TMPS remains in the standby mode until the spinup mode is initiated by an FTB operator controlling the Fire Control System in MCC.

In the spinup mode, TMPS supplies an additional 30 V d.c. signal to the guidance system. The guidance system uses this signal to generate resolver excitation power, missile blower power, gyro spinup power, and inertial component magnetic suspension power. During the spinup mode, TMPS monitors the missile reference signals from the guidance system and maintains the power and monitoring functions provided during the standby mode. The duration of the spinup mode is controlled by a one-minute timer in TMPS. Upon expiration of this timer, TMPS automatically enters the operate mode.

In the operate mode, TMPS supplies a third 30 V d.c. signal to the guidance system. This signal is used by the guidance system to develop power for the guidance system computational circuits. During the operate mode, TMPS monitors the slewing rate of the gimbal assembly and maintains all power and monitoring functions provided during the standby and spinup modes.

Power Supplies

The TMPS provide prelaunch external power to the missile and internal power for the operation of TMPS. There are four TMPS power supplies, two internal power supplies, a guidance power supply, and a flight control power supply. All four power supplies use 120 V, 400 Hz, 3-Ø power from the ship and weapon system distribution equipment to generate the necessary d.c. outputs.

The guidance power supply generates three 30 V d.c. signals, (one for each mode of operation) and routes them to the guidance system via the missile electrical subsystem. During the standby mode, the guidance power supply generates a 30 V d.c. signal, guidance external standby power, and routes it to the guidance system. In the spinup mode, the guidance power supply generates a second 30 V d.c. signal, guidance external spinup power, and routes it to the guidance system. In the operate mode, the guidance power supply generates a third 30 V d.c. signal, guidance external operate power, and routes it to the guidance system.

The flight control power supply generates and routes a 30 V d.c. signal, flight control electronics external power, to the missile electrical subsystem. The flight control power supply is controlled by the control and display subsystem and MTRE Mk 6 and is not dependent on the TMPS mode of operation. When enabled, the flight control power supply supplies the 30 V d.c. signal to the missile until the missile is transferred to internal power.

Monitoring Circuits

The TMPS monitoring circuits monitor the guidance system temperature, missile reference signals, and gimbal runaway condition. If the monitoring circuits detect an alarm condition, the monitoring circuits generate a spinup inhibit, reset to standby, or a power dump signal and route it to the TMPS guidance power supply. The spinup inhibit signal inhibits TMPS from entering the spinup mode, the reset to standby signal resets TMPS to standby mode, and the power dump signal removes all power from TMPS to the guidance system.

The monitoring circuits monitor gyro and accelerometer temperature sensor signals from the missile guidance system for any temperature variations. Any variation of temperature beyond a prescribed limit causes TMPS to be reset to the standby mode. The monitoring circuits also monitor for the presence of the guidance coolant flow signal from the guidance system coolant flow gauge in the ship system. (This system is used to maintain missile internal temperature within prescribed limits.) The presence of the guidance coolant flow signal indicates that the coolant flow rate is within prescribed limits. Loss of this signal resets TMPS to the standby mode and inhibits TMPS from entering the spinup mode.

The 800 Hz and 9600 Hz missile reference signals from the guidance system are monitored to ensure that the signals are within allowable limits. If the reference signals do not reach the proper operating level within the designated time, or if they fall below the operating level, TMPS is reset to the standby mode. If the reference signal exceeds the operating level, TMPS initiates a power dump.

The monitoring circuits also monitor the slewing rate of the gimbal assembly to ensure that a gimbal runaway condition does not exist or occur. Gimbal runaway is the condition when gimbals are slewed too fast. An excessive slewing rate will damage the inertial components. The outer, middle, and inner gimbal servo error signals [e(DAmj), e(DAmr), and e(DAmv)], and outer, middle, and inner gimbal rate monitor signals (OGRM, MGRM, and IGRM) from the guidance system are monitored to ensure that they are within the allowable limits. If any of these signals exceeds the limits, TMPS is reset to the standby mode. During command slew operation, a portion of the monitoring circuits receives the outer, middle, and inner gimbal command slew signals (OGCS, MGCS, and IGCS) from CSSS, and routes them to the guidance system. These signals are used to position the guidance system gimbals to the approximate aligned and erected position. Remember, these functions are all monitored by the control and display subsystem portion of the Fire Control System in MCC.

At launch first motion, the missile lifts off the support ring, and a missile away signal is routed from the launcher control panel (LCP) in the launching system to the monitoring circuits. This signal causes the TMPS monitoring circuits to generate a power dump signal that is routed to the power supplies. The power dump signal deactivates TMPS.

MASTER CLOCK AND TIMING SUBSYSTEM

MCTSS generates and distributes clock pulses, timing terms, and synchronization signals that are used by the digital circuits throughout the Fire Control System to process data. The clock pulses establish a basic time reference on which timing terms are based and provide logic element triggering signals to enable data transmission. The timing terms provide a means of identifying the digital logic and coordinating multiple digital operations. The synchronization signals maintain operational coincidence between the digital circuits in the Fire Control System. MCTSS contains two master clock assemblies (MCA), three master timer assemblies (MTA), two tactical distribution circuits, and a test distribution circuit.

Master Clock Assembly

The MCAs generate and distribute continuous trains of both normal and delayed clock pulses. Both MCAs are operating simultaneously, but the outputs of only one MCA are used. The other MCA enables us to maintain the normal firing rate in the event of a casualty, and it is in standby.

Normal clock pulses control the leading and trailing edges of all timing terms and thereby maintain a constant relationship between the timing terms. Delayed clock pulses trigger the logic elements of the digital circuits to process the data. (The delayed clock pulses occur approximately one-half cycle after the normal clock pulses.) Because of the characteristics of logic elements, data must be applied to the input of an element some finite time before the element can be triggered to process the data. Normal clock pulses and data pulses arrive at the logic element input at the same time. Consequently, the use of the normal clock pulse as a trigger pulse would cause a delay in processing the data. To avoid this delay, the delayed clock is used as the trigger pulse, and the data is processed through the logic element within the same time period that the data occurs at the input.

Normal clock pulses are routed to the MTA to be used in the generation of the basic timing terms. Both normal and delayed clock pulses are routed to the distributive timing circuits to be distributed to the fire control digital circuits.

Master Timer Assembly

The MTAs generate basic timing terms and synchronization signals, using the normal clock pulses from the MCA. MTA1 and MTA2 generate timing terms and synchronization signals for the fire control tactical equipment. MTA3 provides similar signals for the test equipment.

The basic timing terms generated by the MTAs provide a continuous time base for digital operations, identify data bits, and enable digital circuit operation at a specific time and in a specific sequence. The synchronization signals synchronize the fire control and DCC clocks, aid in controlling DCC inputs, and synchronize the fire control channels to ensure that only one missile is fired at a time during a launch sequence.

The MTAs route the basic timing terms and synchronization signals to the distributive timing circuits for further distribution and the generation of compound timing terms.

Distributive Timing Circuits for Tactical Assemblies

The distributive timing circuits for tactical assemblies provide clock pulses, timing terms, and synchronization for logic gating. The tactical assemblies that contain distributive timing circuits are the parallel to serial converter (PSC), DRISS, and the missile motion A/D converter. One tactical distributive timing circuit, in conjunction with MTA1 provides timing for fire control channel 1 and control functions for missiles 1 through 8. The second tactical distributive timing circuit, in conjunction with MTA2, provides timing for fire control channel 2 and control functions for missiles 9 through 16.

Distributive Timing Circuit for Test Assemblies

The distributive timing circuit for test assemblies provides timing pulses and terms necessary to synchronize logic gating for the digital test equipments. Simulated signals for test purposes are also provided. The digital test equipments are the accelerometer pulse converter (APC), the DFCTE, and the simulated accelerometer assembly (SAA).

MCTSS functions are monitored by an operator at the control console, who is prepared to take corrective action if required.

CONTROL AND DISPLAY SUBSYSTEM

The control and display subsystem allows us to initiate, control, and monitor the major events and operational sequences of the weapon system during all modes of operation. CDSS also monitors fire control and weapon system equipment operations for equipment operational readiness or malfunction condition.

Through the CDSS we establish the operational mode of the weapon system by initiating one of the nine system modes of operation: tactical, dummy, training with guidance system, training without guidance system, FC test, missile test, fuze set test, MCC standby, and OFF. Only the tactical mode will be covered in this chapter. We use the tactical mode to check, prepare, and sequentially launch 16 missiles; it is the only mode in which an actual tactical missile may be fired. When we select the tactical mode, we cause the CDSS to generate and route command and control signals to fire control and weapon system equipment to interconnect and activate all the equipment necessary to perform the tactical functions.

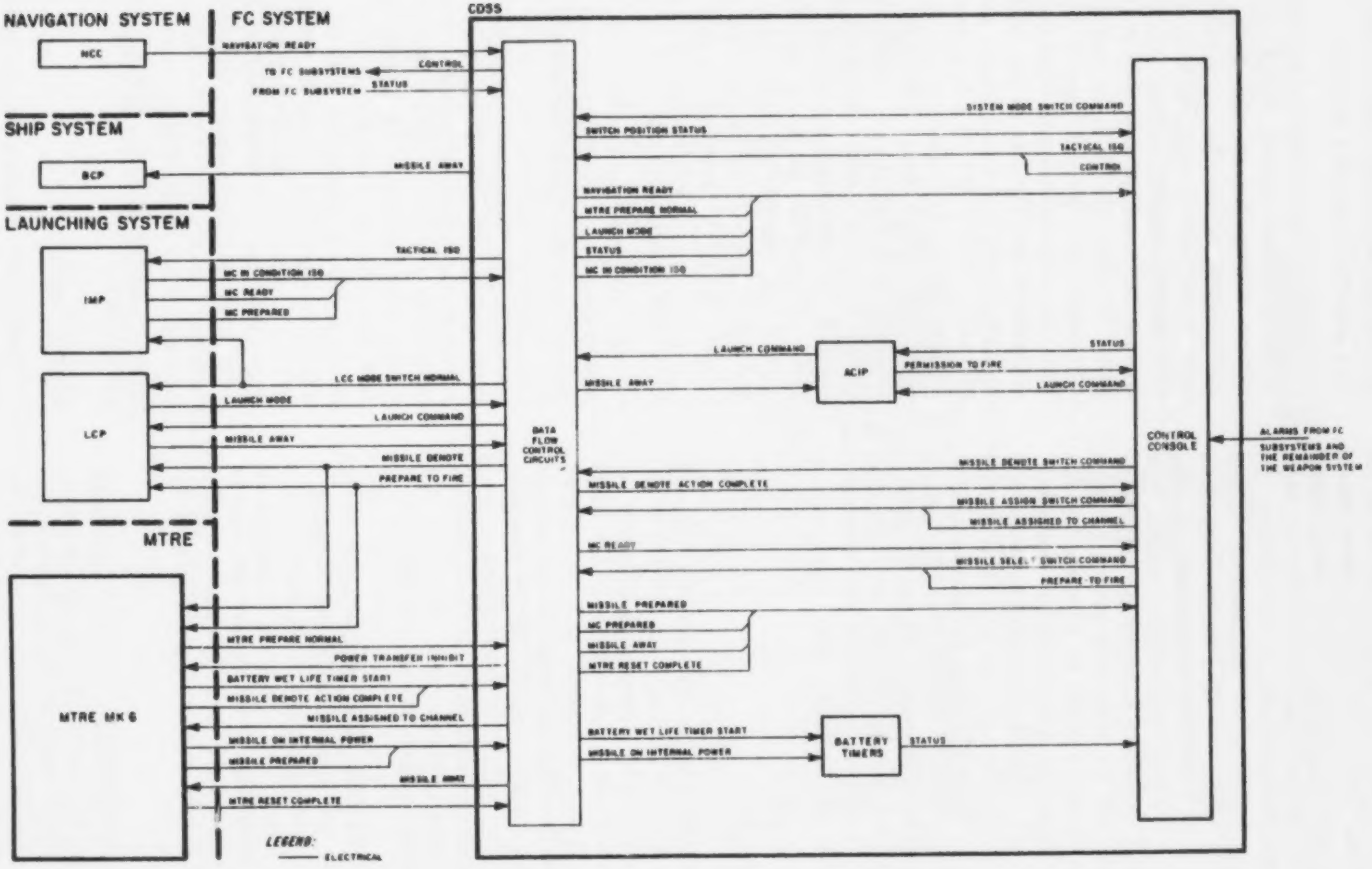
The monitoring functions of the CDSS determine the operational readiness of the weapon system and detect any equipment malfunctions. If a malfunction occurs, the weapon system equipment that detects the malfunction generates and routes an alarm signal to the CDSS. The alarm signal causes one of the following conditions to occur: missile bypass, missile hold, channel hold, or channel inhibit.

A missile bypass results from a malfunction in missilized equipment that requires a relatively long correction time. A missile hold results from a malfunction in missilized or channelized equipment that requires a relatively short time to correct. A missile bypass removes all power to a missile except guidance system heater power. A missile hold prevents a missile from being channelized. If the missile is channelized when the hold occurs, the missile is reset out of the channel. The channel hold prevents the initiation of new channelized functions, but allows those functions in progress to continue. Most alarm conditions that generate a channel hold also request a channel inhibit. Channel inhibit prevents any missiles from entering the channel. All of these functions are monitored by the Fire Control System operators in MCC.

CDSS (fig. 3-3) consists of the Attack Center Indicating Panel (ACIP), the Control Console, data flow control circuits, and the battery timers. The CDSS components interact to control the operational data flow during weapon system operations.

Attack Center Indicating Panel

The ACIP provides the commanding officer with the status of each missile and the weapon


NAVIGATION SYSTEM
FC SYSTEM
CDSS
NCC
NAVIGATION READY
CONTROL
TO FC SUBSYSTEMS
STATUS
FROM FC SUBSYSTEM
SHIP SYSTEM
BCP
MISSILE AWAY
LAUNCHING SYSTEM
IMP
TACTICAL ISO
MC IN CONDITION ISO
MC READY
MC PREPARED
LCP
LCC MODE SWITCH NORMAL
LAUNCH MODE
LAUNCH COMMAND
MISSILE AWAY
MISSILE DENOTE
PREPARE TO FIRE
MTRE
MTRE MK 6
MTRE PREPARE NORMAL
POWER TRANSFER INHIBIT
BATTERY WET LIFE TIMER START
MISSILE DENOTE ACTION COMPLETE
MISSILE ASSIGNED TO CHANNEL
MISSILE ON INTERNAL POWER
MISSILE PREPARED
MISSILE AWAY
MTRE RESET COMPLETE
LEGEND:
ELECTRICAL
DATA FLOW CONTROL CIRCUITS
SYSTEM MODE SWITCH COMMAND
SWITCH POSITION STATUS
TACTICAL ISO
CONTROL
NAVIGATION READY
MTRE PREPARE NORMAL
LAUNCH MODE
STATUS
MC IN CONDITION ISO
LAUNCH COMMAND
ACIP
STATUS
PERMISSION TO FIRE
LAUNCH COMMAND
MISSILE AWAY
CONTROL CONSOLE
ALARMS FROM FC SUBSYSTEMS AND THE REMAINDER OF THE WEAPON SYSTEM
MISSILE DENOTE SWITCH COMMAND
MISSILE DENOTE ACTION COMPLETE
MISSILE ASSIGN SWITCH COMMAND
MISSILE ASSIGNED TO CHANNEL
MC READY
MISSILE SELECT SWITCH COMMAND
PREPARE TO FIRE
MISSILE PREPARED
MC PREPARED
MISSILE AWAY
MTRE RESET COMPLETE
BATTERY WET LIFE TIMER START
MISSILE ON INTERNAL POWER
BATTERY TIMERS
STATUS

173.493

Figure 3-3.—Control and Display Subsystem Data Flow.

system and affords him positive control of the firing circuit. The ACIP receives status signals from the control console. These status signals indicate the status of each missile (bypass, hold, 1SQ, assign, prepare, and missile away), the operational readiness of the weapon system (1SQ or not 1SQ), and the selected firing mode (automatic or manual) determined by the operator. These indications enable the commanding officer to monitor the progress of the launch and to determine when to issue permission to fire. The CO uses the tactical fire switch to issue the permission to fire signal. Actuating the tactical fire switch closes the firing circuit and generates the permission to fire signal. Thus, the tactical fire switch enables the commanding officer to maintain positive control of the launch until the launch command signal is generated. This is one of the many positive controls that selected personnel have to ensure that missiles are launched only upon proper command.

Control Console

The control console provides the weapon's control officer (WCO) and the Fire Control System operator with operational control of the weapon system and a visual display of the status of weapon system equipment and the progress of the launch. The portions of the control console used during a missile launch consist of the missile-to-fire order patch panel, DCC-to-equipment configuration panel, and the operating panel. Figure 3-4 illustrates the control console and the various sections.

PATCH PANEL.–The missile-to-fire order patch panel provides a means for assigning a missile to a position in the firing order. In the automatic mode, the patching arrangement established by the panel determines the order in which the missiles are fired. Normally, missiles assigned to targets with the highest priority are launched first.

DCC TO EQUIPMENT CONFIGURATION PANEL.–The DCC-to-equipment configuration panel controls and monitors the configuration of each DCC and the equipment external to the DCCs. The panel controls several different DCC to external equipment configurations. (This will be discussed in the next chapter.)

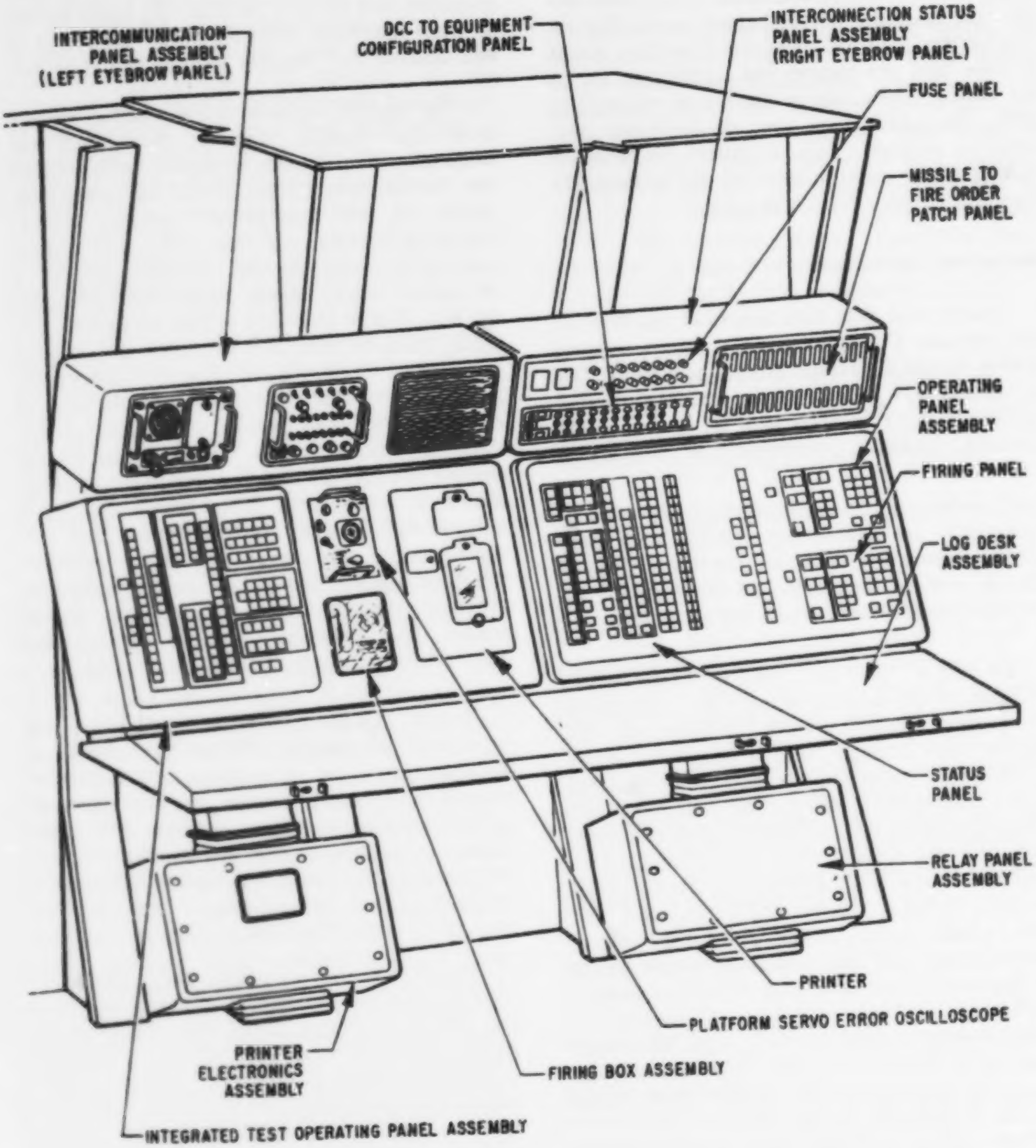
OPERATING PANEL.–The operating panel is the principal control center of the weapon system during launch operations. Commands and control signals that establish the weapon system and Fire Control System configuration and initiate weapon system and Fire Control System functions are generated at the operating panel by you, the FTB. In response to these commands and control signals, the operating panel receives status signals from the fire control subsystems and the rest of the weapon system for monitoring and visual display purposes. The operating panel is divided into a status panel and a firing panel. The status panel allows you to select the system mode of operation, and to monitor the operational status of weapon system equipment, and control and monitor the progress of missilized operations. The firing panel allows you to select the firing mode, initiate and monitor the channelized sequences, and cause the launch command from the Fire Control System to be generated.

Data Flow Control Circuits

The data flow control circuits establish the proper equipment configuration and control the flow of data throughout the weapon system and Fire Control System for each mode of operation. The data flow control circuits consist principally of switching assemblies that automatically intraconnect fire control subsystems and interconnect the Fire Control System with the rest of the weapon system. The data flow control circuits consist of status and power switching assemblies that are positioned when the operating mode is selected on the control console and sequence switching assemblies that are positioned in accordance with predetermined sequential events. These switching assemblies are located on posts throughout the missile control center and on the missile compartment (MC) fire control switchboard.

Battery Timers

The battery timers indicate the wet life and load life time of the missile batteries. The


INTERCOMMUNICATION PANEL ASSEMBLY (LEFT EYEBROW PANEL)
DCC TO EQUIPMENT CONFIGURATION PANEL
INTERCONNECTION STATUS PANEL ASSEMBLY (RIGHT EYEBROW PANEL)
FUSE PANEL
MISSILE TO FIRE ORDER PATCH PANEL
OPERATING PANEL ASSEMBLY
FIRING PANEL
LOG DESK ASSEMBLY
STATUS PANEL
RELAY PANEL ASSEMBLY
PRINTER
PLATFORM SERVO ERROR OSCILLOSCOPE
PRINTER ELECTRONICS ASSEMBLY
FIRING BOX ASSEMBLY
INTEGRATED TEST OPERATING PANEL ASSEMBLY

173.495

Figure 3-4.—Control Console.

battery timers consist of a battery activation timer and a battery load life timer for each missile. The battery activation timer indicates the time since the missile battery was activated. The battery load life timer indicates the amount of time that the battery has supplied power to the missile. These timers allow us to monitor, in MCC, the actual clock time the functions have been in progress. This is critical for decision making in the event missiles are not sequentially launched during a tactical sequence.

Operational Data Flow

Operational data flow describes the flow of data between CDSS and the rest of the weapon system during a strategic launch operation. The events and flow of data during a strategic launch operation occur in three stages: system mode selection, missilized operations, and channelized operations.

Normally, all interface signals (refer back to figure 3-3) are routed through the data flow control circuits in CDSS, but for the purpose of this discussion, the routing of these signals via the data flow control circuits will be omitted.

SYSTEM MODE SELECTION.—The selection of the tactical system mode establishes the proper weapon system configuration and initiates the strategic launch sequence. When you select the tactical mode (only when directed by the commanding officer), the control console routes a tactical system mode switch command signal to the data flow control circuits. In response to the command signal, the data flow control circuits automatically position the power and status switches to the correct position and route switch position status signals to the control console. The data flow control circuits also route a launch control center (LCC) mode switch normal signal to the integrated monitoring panel (IMP) and launcher control panel (LCP) and a power transfer inhibit signal to the MTRE Mk 6. The LCC mode switch normal signal indicates that the launching system is interconnected with fire control for a launch sequence. The power transfer inhibit signal prevents MTRE from prematurely generating the command to transfer the missile to internal power. When all the switches are properly positioned, the control console generates and routes a tactical 1SQ signal to IMP to keep operators there aware of the status of fire control and weapon system configuration.

The control console receives status reports from the various stations throughout the weapon system. The status reports inform CDSS and the fire control operator of the operational status of the navigation system, MTRE, launching system, and the other fire control subsystems. The control console receives a navigation ready signal from the navigation control console (NCC), a MTRE prepare normal signal from MTRE, and a launch mode signal from the LCP. Fire control subsystems monitored for operational readiness include the OAG, MCTSS, DCC group, MMSS, and SGSS. Each subsystem routes status signals to the control console. In addition, the control console monitors power and temperature conditions within the missile control center and the condition of the power and status switches. When all weapon system equipment is operating properly, through the control console, control signals are generated to the fire control subsystems to initiate missilized operations.

MISSILIZED OPERATIONS.—Missilized operations are functions that are performed simultaneously on all missiles and consist of supplying external power to the guidance system, coarse and fine erection and coarse alignment of the missile stable platform, and missilized digital operations by the DCC. Again, remember that all of these functions are initiated by the Fire Control System operator.

On receipt of a control signal from the control console, TMPS routes spinup power to the guidance system. TMPS then monitors the guidance system for an 800 Hz reference signal. When the reference signal is obtained, TMPS routes a status signal to the control console. This status signal, combined with the system operating mode signal, generates a control signal that is routed to the fire control subsystems to initiate their missilized functions. During missilized operations, the fire control subsystems generate launch bearing, Earth rate, and erection and alignment torquing signals that position the missile stable platform.

Guidance initialization is the first function to be initiated. Guidance initialization is a channelized operation performed during missilized operations and consists of the command slew process, initial missile data readin to the guidance computer, and verification of the proper transfer of data to the guidance computer. After gyro spinup, the missiles are momentarily removed from missilized operations and entered into channelized operations. The first two missiles in the firing order are selected for the guidance initialization sequence. The outer, middle, and inner gimbals of the selected missiles are rapidly positioned to their approximate aligned and erected positions. Simultaneously, the control console receives a missile assign switch position status signal from the data flow control circuits, indicating the status of the switch, the number of the missile that is in channel, and the DCC data which determines the proper data readin sequence.

If the missile number contained in the data being computed by the DCC coincides with the number of the channelized missile, the control console routes control signals to the fire control subsystems. The control signals cause the fire control subsystems to begin initial missile data readin and verification. The missile data are computed by the DCC and MMSS. The DCC computes guidances data, and the MMSS computes missile motion data. The missile motion data are routed to the DCC, where they are routed along with the guidance data to the guidance system via DRISS. After these data are stored, they are routed back to the DCC, where they are compared with the original data to ensure accurate data transmission. At the completion of data verification and when a command slew null is received by the control console, the missile is reset from channel. This process continues until the guidance initialization sequence has been performed on all missiles, at which time the sequence is manually terminated by the fire control operator.

When the missilized functions for a missile are complete, and when the control console receives an MC in Condition 1SQ signal from IMP, the missile is considered to be in Condition 1SQ and is ready for the channelized operations. The missilized functions continue until all 16 missiles are at Condition 1SQ.

Before initiating the channelized operations, a channel check is made to verify the operations of the channelized equipment. Channel check is manually initiated by the fire control operator when two or more missiles have reached Condition 1SQ. When channel check is initiated, a missile is entered into each channel, and all channelized operations are performed except MTRE and launching system functions. After successful completion of channel check, the missile is returned to the unchannelized state.

CHANNELIZED OPERATIONS.– Channelized operations are performed on one missile at a time. There are two separate channels, and each channel performs the same functions in preparing a missile for launch.

When a predetermined number of missiles have reached Condition 1SQ, a weapon-system-at-1SQ-status signal is generated by the fire control operator at the control console and routed to the ACIP. In response to this signal, the commanding officer causes a permission to fire signal to be generated at the ACIP and routed to the control console. Channelized operations are then initiated by the fire control operator by selecting the firing mode (manual or automatic). In the automatic mode the missiles automatically enter the channelized operations according to the predetermined firing order. Channelized operations are performed during two separate sequences, denote and assign.

When the firing mode has been selected, the control console routes a missile denote switch command signal to the data flow control circuits and removes the power transfer inhibit signal to MTRE. The data flow control circuits position the missile denote switches for the first two missiles in the firing order to a channel position and route a switch position status signal to the control console. The missiles are now in the denote position of each channel, and a missile denote signal is routed from the data flow control circuits to MTRE and the LCP. The switch position status signal indicates the numbers of the denoted missiles on the control console, and the missile denote signal initiates denote operations in the launching system and MTRE.

During the denote sequence, the launching system begins pressurizing the missile tubes. The pressurization operation continues throughout the denote sequence and into the assign sequence. In denote, MTRE activates the missile battery for each missile and performs initial go/no-go checks on the missile. When a battery is activated, MTRE routes a battery wet life timer start signal to the battery timers. Upon receipt of the signal, the appropriate battery activation timer starts. Upon successful completion of the missile go/no-go checks, MTRE generates and routes a missile denote action complete signal to the control console for the operator's information.

On receipt of the missile denote action complete signal, the control console generates and routes a missile assign switch command signal to the data flow control circuits. Automatically, the missile assign switches associated with the denoted missile are driven to the appropriate channel position, and the missile denote switches are driven to OFF. The control console receives a missile assign switch position status signal from the data flow control circuits, which indicates the status of the switch and the number of the missile that is in assign. This signal also initiates the initial DCC fine bearing data computations for that missile. The same process occurs for the other missile when it has completed the denote sequence. If the missile number contained in the data being computed by the DCC coincides with the number of the assigned missile, the control console generates and routes a missile assigned to channel signal to MTRE. The missile assigned to channel signal causes MTRE to initiate a series of missile checks. The DCC routes more precise launch bearing signals to the ALNSS. The presence of these signals initiates fine alignment preparations. ALNSS positions the fine align servos until they are nulled, at which time ALNSS routes a fine align servo null status signal to the control console.

In addition to ALNSS, the control console monitors the channelized operations being performed by PWRSS, MCTSS, CSSS, and MMSS. Channelized equipment and functions monitored include fire control channel power and timing, an erection check, and missile motion data conversion. This allows the fire control operator to continuously monitor the status of the subsystems and the progress of events.

When the launching system has completed its denote operations on one of the missiles and is ready to begin final missile preparations for that missile, IMP generates and routes an MC ready signal to the control console. The presence of the MC ready signal initiates the OAG start sequence and inhibits further operations in the other channel. When fine alignment preparations are complete, the control console generates and routes a missile select switch command signal to the data flow control circuits. Automatically the missile select switches associated with the desired missile are driven to the channel position. When the switches are properly positioned, the control console receives a missile select switch position status signal from the data flow control circuits. The presence of this signal causes the control console to route a control signal to ALNSS, initiating the fine alignment process. When fine alignment is complete, the control console routes a prepare-to-fire signal to LCP and MTRE.

The launching system responds to the prepare-to-fire signal by initiating final launching system preparations such as missile hatch (MH) opening sequence and readying of the eject system for a launch. When the launching system preparations are complete (MH locked open and eject system firing units are charged) and MC is prepared to launch a missile, IMP routes an MC prepared signal to the control console.

On receipt of the prepare-to-fire signal, MTRE initiates a series of final missile checks and preparations. The MTRE sequence of checks stops at step 9 until the launching system has completed the MH opening sequence. When CDSS receives the MC prepared signal from the launching system, the data flow control circuits in CDSS remove the power transfer inhibit signal from MTRE, permitting MTRE to advance to step 10 of its sequence and transferring the missile from external power to internal power.

(The missile batteries were activated during the first stage of denote sequence.) MTRE monitors the transfer and, when it is successfully completed, routes a missile on internal power signal to the battery load life timer associated with the selected missile. The missile on internal power signal starts the battery load life timer. MTRE continues with the remaining missile checks and preparations, and when completed, routes a missile prepared signal to the control console.

When the MC and missile are prepared, final guidance data and fuze set data readin and verification are initiated. The guidance data generation is identical to that performed during guidance initialization, using the latest updated information. The fuze set data are computed by the DCC and routed to the missile via the fuze set subsystem (FSSS). If the data verification is satisfactory, the control console generates a launch command signal (caused by the WCO closing the firing key), and routes it through the ACIP to the LCP, initiating a missile launch.

As the missile leaves the tube, a missile away signal is generated at the LCP and routed to the data flow control circuits. The data flow control circuits route the missile away signal to the ACIP, control console, ballast control panel (BCP), and MTRE. The ACIP and control console display the missile away signal to notify the CO and WCO and fire control operator that the missile has been launched. The BCP displays the missile away signal to notify the BCP operator to begin the compensation procedures required to maintain the ship in a stable attitude with the weight change caused by the missile launch. On receipt of the missile away signal, MTRE initiates a MTRE reset sequence. When the reset sequence is complete, MTRE routes a MTRE reset complete signal to the control console. The presence of the missile away signal and MTRE reset complete signals at the control console resets the channelized equipment, clearing the channel for the next missile. This process continues in each channel until all 16 missiles are launched.

COMMAND SLEW SUBSYSTEM

CSSS generates torquing signals that cause rapid positioning of the outer, middle, and inner gimbals of the missile guidance system to the approximate aligned and erected position, thereby reducing the time required for the normal alignment and erection processes. During the normal alignment and erection processes, the gimbals are positioned at the rate of 0.1 degree per second because of the limited torquing rate of the inertial reference integrating gyro (IRIG) servo loop. During command slew, the CSSS outputs are applied directly to the gimbal torque motors, bypassing the IRIG servo loops. Applying these signals directly to the gimbal torque motors permits the gimbals to be positioned at a maximum rate of up to 30 degrees per second. After command slew is complete, the gimbal torquing control is returned to ALNSS and ESS to complete the alignment and erection processes.

Command slew is automatically enabled when tactical, TWIG, or TWOG mode of operation is selected. Immediately after gyro spinup, the first two missiles in the firing order are assigned to channel and are connected to CSSS. These actions initiate the command slew process. The outer and middle gimbals are slewed first. Upon receipt of a null from the outer and middle gimbals, the inner gimbal is slewed. When all three gimbals are nulled and DRISS has completed the guidance initialization sequence for that missile, the missile is removed from channel. The next missile in the firing order is automatically placed in that channel, and the process is repeated. This continues until all 16 missiles are command slewed, at which time command slew is manually terminated by the fire control operator.

CSSS Control Loops

Within each CSSS there are three control loops, one for each guidance system gimbal. Each control loop generates signals to torque one of the guidance system gimbals (outer, middle, or inner) to the desired position. The control loops receive analog signals consisting of missile pitch, Eim; missile roll, Zvm; relative missile heading, Bmr; ship pitch, Eio′; ship roll, Zo; ship heading, Cqo′; and launch bearing, Byrg. These signals are routed to the control loops from the MMSS and SGSS, converted into d.c. signals, and routed to the missile guidance system.

Each control loop operates similarly, the only difference being the inputs used to generate the command slew torquing signals. Therefore, only the outer control loop will be discussed. The outer control loop receives the Eim-Eio′ analog signal from the MMSS (fig. 3-5) and converts this signal to d.c. Eim-Eio′ is a result of comparing the position of the missile pitch gimbal with the position of the SINS pitch gimbal and is accomplished in the MMSS. The outer control loop amplifies and routes the d.c. signal to TMPS as the OGCS signal. TMPS routes the OGCS signal to the guidance system to torque the missile outer gimbal to the desired position. The control loops are closed-loop servo systems, and as the angle between the missile and SINS gimbals decreases, the magnitude of the command slew signal decreases. The middle control loop receives Zvm-Zo from the MMSS and generates the MGCS signal. The inner control loop receives Byrg-Cqo′-Bmr from the SGSS and generates the IGCS signal.

The OGCS and MGCS signals torque the outer and middle gimbals to the approximate local vertical, and the IGCS signal torques the inner gimbal to the approximate launch bearing. CSSS controls the positioning of the gimbals for a maximum of 15 seconds. If a command slew null is not generated for a particular missile, within the 15 seconds, an alarm signal is generated and routed to CDSS, causing a channel hold. The fire control operator then must make the proper decision and take corrective action.

The erection and alignment torquing signals are routed to the missile guidance system while command slew is in process, but the command slew signals override these torquing signals. At the completion of command slew, the missile is reset from channel and the erection and alignment torquing signals control the orientation of the stable platform.

OPTICAL ALIGNMENT GROUP

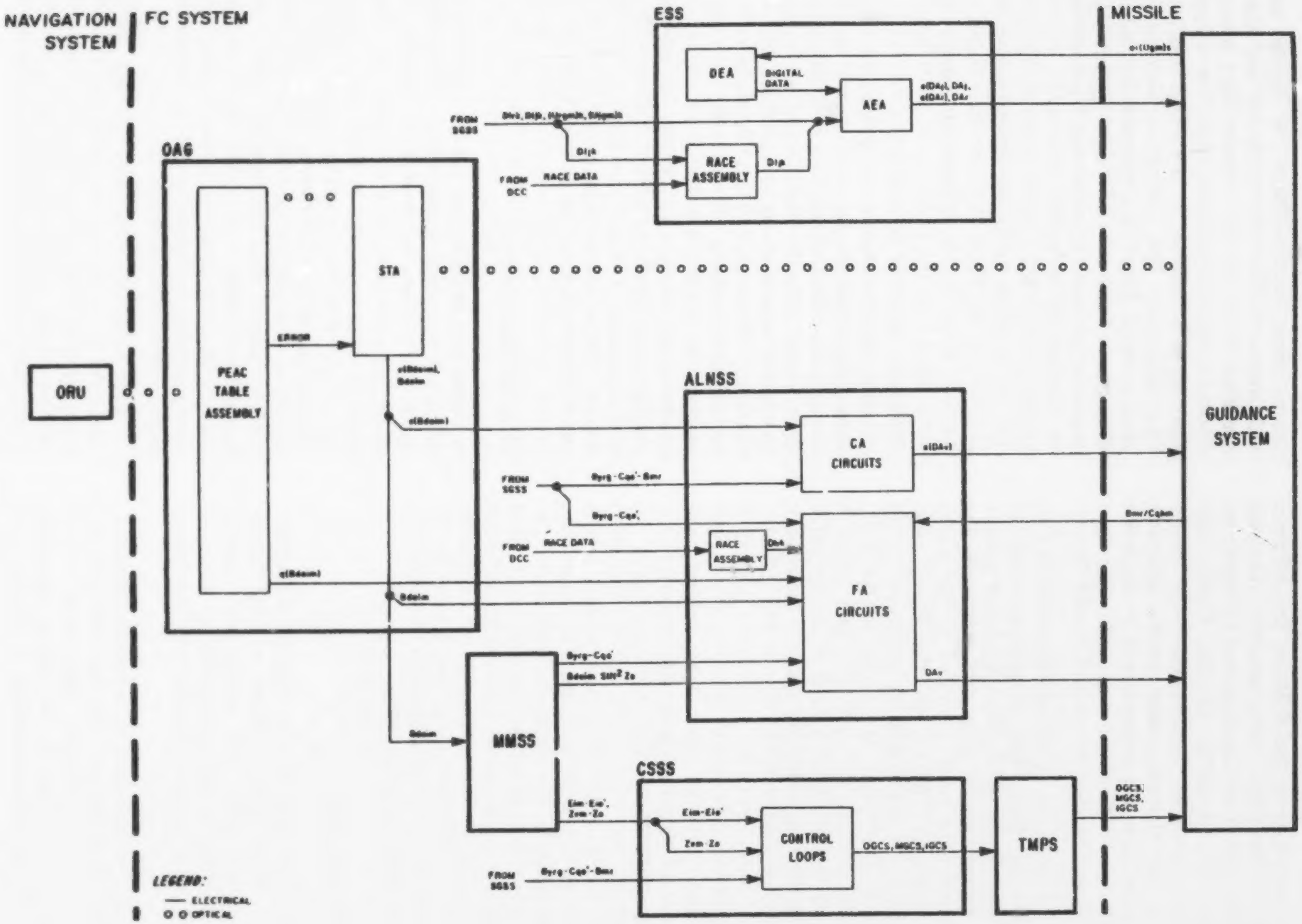
The OAG provides a measurement of the misalignment angle between the missile zero reference and the ship zero reference. This measurement is used by the ALNSS in the solution of the alignment problem. Failure to compensate for this misalignment prior to launching a missile would adversely affect the accuracy of the missile flight. The three factors that contribute to the misalignment error are initial placement of the missile in the launch tube, movement of the missile in the tube while on patrol, and ship flexures (twisting of the ship's structures by external pressures). During initial onloading of the missiles, it is virtually impossible to position the missile zero reference precisely to the ship zero reference. Therefore, some angle of misalignment is present. The OAG monitors the installation of the missiles to ensure that the misalignment angle does not exceed specified limits. The movement of the missile in the tube and ship flexure errors are monitored and compensated for periodically while on patrol.

During the coarse alignment process, the OAG provides an approximation of the misalignment angle to the ALNSS. This approximation is a static value and consists of the last known measurement (initially this angle consisted of the misalignment angle detected during the initial onloading of the missile). Fine alignment requires a more exact measurement of the misalignment angle. The OAG provides a dynamic value of the misalignment angle for the fine alignment process, including the static, the missile movement in the tube, and ship flexure values.

The OAG performs three measurements to obtain the missile misalignment angle. These are known as reference measurement, static measurement, and dynamic measurement. The reference measurement is taken between the photoelectric autocollimator (PEAC) table assembly in the missile compartment and the ORU in the navigation center. The static measurement is taken between the PEAC table assembly in the MC and the porro prisms of the missiles. The dynamic measurement consists of both the reference and static measurements.

Reference Measurement

The reference measurement provides the OAG with the ship zero reference by translating


NAVIGATION SYSTEM
FC SYSTEM
MISSILE
ORU
OAG
PEAC TABLE ASSEMBLY
ERROR
STA
e(Bdeim), Bdeim
e(Bdeim)
e(Bdeim)
Bdeim
Bdeim
ESS
DEA
DIGITAL DATA
AEA
e(DAi), DAi, e(DAr), DAr
e(Ugm)s
FROM SGSS
Dir, Dip, (Ugm)r, (Ugm)s
Dip
RACE ASSEMBLY
Dip
FROM DCC
RACE DATA
ALNSS
CA CIRCUITS
e(DAr)
FROM SGSS
Byrg-Cqo'-Bmr
Byrg-Cqo'
FROM DCC
RACE DATA
RACE ASSEMBLY
DrA
FA CIRCUITS
Bmr/Cqbm
DAr
MMSS
Byrg-Cqo'
Bdeim SIN² Zo
CSSS
Eim-Eio',
Zom-Zo
Eim-Eio'
Zom-Zo
CONTROL LOOPS
OGCS, MGCS, IGCS
FROM SGSS
Byrg-Cqo'-Bmr
TMPS
OGCS, MGCS, IGCS
GUIDANCE SYSTEM
LEGEND:
— ELECTRICAL
O O OPTICAL

258.11

Figure 3-5.—Optical Alignment Group, Command Slew Subsystem, Alignment Subsystem, and Erection Subsystem Data Flow.

the reference from the ORU to the reference PEAC on the PEAC table assembly. The ship zero reference is used to align port and starboard PEACs, also mounted on the PEAC table assembly, when the OAG equipment is initially aligned. The reference measurement is also taken during the dynamic measurement to determine any change in PEAC table assembly alignment with respect to the ORU caused by ship flexure.

To obtain the reference measurement (fig. 3-5) the reference PEAC projects a collimated light beam to the ORU. The ORU has previously been aligned to the ship zero reference. The collimated light beam is routed via the wedge drive assembly (WDA), on the PEAC table assembly, and the alignment periscope. If the projected light beam is normal to the ORU reference mirror, the reflected light beam is returned to the PEAC parallel to the projected beam, indicating no misalignment. If the beam is not normal to the ORU mirror, the reflected beam will not be parallel, indicating misalignment. The PEAC measures the angular difference between the light beams and generates an electrical signal proportional to the angular difference. The electrical signal is applied to the WDA servo motor. The servo motor drives a set of optical wedges and a resolver in the WDA until the light beams are parallel (nulled). The electrical signal driving the servo motor is then nulled, the motor stops, and the resolver is positioned to a mechanical value of misalignment. The resolver is then excited by an 800 Hz reference voltage which produces an electrical value of misalignment between the reference PEAC and the ORU.

Static Measurement

The static measurement provides the ALNSS with a close approximation of the missile misalignment angle. This measurement consists initially of the misalignment detected when the missiles were originally loaded into the launch tubes.

Static measurement is a process similar to reference measurement. The port and starboard PEACs project collimated light beams to the missile porro prisms via the station assemblies (STA) during the onloading operation. The measurement ensures that the missile zero reference and ship zero reference are within specified limits. If the projected light beam is normal to the missile porro prism, the reflected light beam is returned to the PEAC parallel to the projected light beam, indicating no misalignment. The PEAC measures the angular difference between the light beams and generates an electrical error signal proportional to the angular difference. The error signal is applied to the WDA servo motor in the STA. The servo motor drives the optical wedges and resolver of the WDA until the light beams are parallel. When the light beams are parallel, the error signal from the PEAC to the servo motor is nulled and the servo motor stops.

The WDA resolver is positioned to a mechanical value proportional to the distance the optical wedges moved in order to parallel the light beams. Once the light beams are parallel, the static measurement is complete and the OAG is deactivated. This measurement is periodically updated during test procedures. During the coarse alignment (CA) process, the resolvers are excited by an 800 Hz reference voltage which produces an electrical value of the static misalignment angle, e(Bdaim), for each missile. The e(Bdaim) signals are routed from the STA to the CA circuits in the ALNSS.

Dynamic Measurement

Dynamic measurement provides the ALNSS with an exact measurement of the misalignment angle and consists of both the reference and static measurements. The reference and static measurements are taken at this time to detect any change in misalignment caused by ship flexure or missile shift in the tube. When the missile is channelized and the fine alignment process begins, the first missile selected for launching activates the OAG. The reference measurement is now taken to detect any change in the ship zero reference caused by ship flexure between the PEAC table and the ORU.

The electrical equivalent of any change caused by this ship flexure, q(Bdaim), is routed from the PEAC table to the fine alignment (FA) circuits in the ALNSS. At the same time, the static measurement is being taken to determine any change in the missile misalignment caused by ship flexure between the PEAC table and the missile porro prisms. Any shifting of the missile caused by ship movement is also detected. The electrical equivalent of misalignment caused by ship flexure and missile shift is call Bdaim. The Bdaim signal is routed from the STA to the FA circuits in the ALNSS, where it is summed with q(Bdaim). The result of this summation is used in the FA process. The Bdaim signal is also routed from the STA to the MMSS to be used in the deck-tilt correction computation.

ALIGNMENT SUBSYSTEM

The ALNSS generates torquing signals that provide the missile with a directional reference. This is accomplished by positioning the missile stable platform r axis to Byrg. The Byrg signal is a result of the base point calculations performed by the DCC (discussed in the next chapter). Byrg is the basis for trajectory computations and for missile guidance. The missile stable platform r axis would normally be aligned to the target bearing, and the guidance system would use this bearing as the basis for its guidance corrections. However, it is necessary only for the r axis to be aligned accurately to a bearing that has a known relationship to the target bearing. The difference between the r axis bearing and the target bearing is compensated for by the guidance system using correction data from the DCC.

The guidance system has the capability of steering the missile along a bearing that differs from aligned bearing by as much as 30 degrees with negligible effect on the accuracy of the flight. Because the alignment process is a mechanical procedure, it is time consuming. Utilizing the guidance system steering capability permits the alignment bearing to be selected and the r axis aligned to that bearing without continual correction and resultant adjustment to that alignment. The correction is digitally computed and entered into the guidance system as guidance data. The digital computations permit last-minute incorporation of the most current conditions.

Byrg is a computation of the target bearing from a base point and will be called the target Byrg. Programmed into the base point calculations is a sector plan based on 60-degree segments, beginning at 0 degree (fig. 3-6). For each of these segments, a central bearing is established, such as at 30, 90, 150 degrees, called the sector Byrg. These segments and bearings use the base point as the point of origin, as do the target Byrg computations.

After computing target Byrg, the DCC determines the segment which contains the target Byrg and the sector Byrg that lie within that segment. All missiles whose target Byrgs lie within that segment are then designated by the DCC to be aligned to that sector Byrg.

The DCC establishes a relationship between the sector Byrg and target Byrg for each missile. Because both Byrg signals originate at the base point, this relationship is constant as long as the applicable base point calculations are valid. This relationship is translated into steering instructions fof the guidance system that result

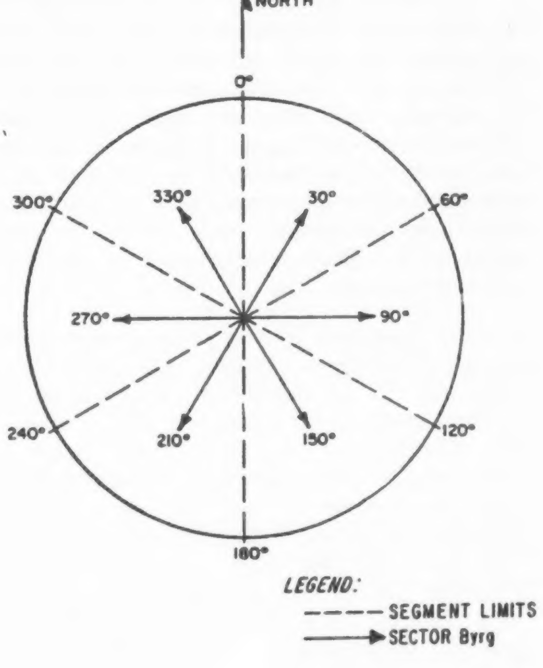


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Figure 3-6.—Alignment Segments Versus Sector Bearings.

in a missile flight along the target Byrg, while the sector Byrg is used as the reference bearing.

To position the r axis, the ALNSS combines all the angles that affect the position of the r axis. These angles are expressed in the alignment formula:

$$\text{Byrg-Cqo}'\text{-Baim-Bmr} = \text{q(Bmr)}$$

The mechanization of this formula by the ALNSS provides the torquing signals that are sent to position the r axis. Each term in the formula represents an angle. The Byrg signal used for alignment is the sector Byrg for a given segment. Cqo′ is the angle between true north and ship zero reference (ownship centerline). Baim, missile misalignment, is the angle between ship zero reference and missile zero reference. Bmr is the angle between missile zero reference and the actual position of the r axis. q(Bmr) is the angle between the actual and desired positions of the r axis.

To make the angles compatible for the mechanization process, all the angle measurements must be taken in the same reference plane. The actual measurements of all the angles except Baim are taken in the Earth horizontal plane. Baim is made up of two quantities, Bdaim measured in the deck plane and one-half the correction for deck tilt (Bdaim SIN^{2}Zo). Summing these two quantities provides the Baim measurement in the Earth horizontal plane.

The alignment process is performed in two modes of operation, coarse and fine. Coarse alignment is a missilized function and is accomplished on all missiles at the same time. The ALNSS contains a separate CA circuit for each missile, which develops individual signals that position the r axis of the 16 stable platforms to the approximate sector Byrg angles. The fine alignment process is a channelized function. The ALNSS contains two FA circuits, each circuit connected to a channel, that generate torquing signals to position the r axes of the channelized missiles to the precise sector Byrg angle. The ALNSS also contains a RACE assembly that processes the Earth rate signal.

Coarse Alignment Circuits

The CA circuits (fig. 3-5) generate torquing signals to position the stable platform r axes to the approximate sector Byrg angles. Coarse alignment begins immediately after guidance system gyro spinup. Each CA circuit receives the Byrg-Cqo′-Bmr signal from the SGSS and the e(Bdaim) signal from the OAG. The Byrg-Cqo′-Bmr signal defines the bearing to which the r axis will be aligned, the ship's heading, and the present position of the r axis. The e(Bdaim) signal is the static value of misalignment between missile zero reference and ship zero reference. The CA circuit sums Byrg-Cqo′-Bmr with e(Bdaim), resulting in the coarse alignment torquing about the v axis, e(Dav), signal that is routed to the missile guidance system. The e(DAv) signal torques the stable platform r axis to a coarse value of sector Byrg.

Fine Alignment Circuits

The FA circuits generate torquing signals to position the stable platform r axis to the precise sector Byrg angle. The FA circuits control the positioning of the r axis once a coarse alignment null is generated and the missile is assigned to channel. Only one missile can be fine aligned at a time. The FA circuits use signals similar to those used by the CA circuits, except the FA circuits use a finer resolution of the signals. This finer resolution provides the ALNSS with a more exact input and consequently, a more exact output.

Each FA circuit receives Byrg-Cqo′ from the SGSS; Earth angular velocity about the v axis, DIvk, signals from the RACE assembly; Bdaim and q(Bdaim) signals from the OAG; Byrg-Cqo′ and Bdaim SIN^{2}Zo signals from MMSS; and the Cqhm signal as Bmr from the guidance system. The Byrg-Cqo′ quantity from the SGSS is a finer resolution than the Byrg-Cqo′ quantity from the MMSS. Use of both quantities permits the FA circuit to generate a more accurate alignment torquing signal. The fine alignment process is accomplished in two steps, fine align servo null and fine align null. Byrg-Cgo′ from the SGSS and Byrg-Cqo′ from the MMSS are used to null the fine align servo. Initially, Byrg-Cqo′ from the MMSS is used. When the servo approaches a null, Byrg-Cqo′ from the SGSS is used. The finer resolution of the signal from the SGSS permits a more accurate positioning of the fine align servo.

Once the fine align servo is nulled, the Bmr signal from the guidance system is applied to the FA servo, yielding the Byrg-Cqo′-Bmr signal. To this basic signal the FA circuit adds Baim, q(Bdaim), Bdaim $\mathrm{SIN}^2\mathrm{Zo}/2$, and DIvk. The result of this summation is the fine alignment torquing about the v axis. DAv, signal that is routed to the guidance system to position the stable platform r axis to a fine value of sector Byrg. The ALNSS maintains the r axis at this position until platform disconnect occurs at launch.

Rate Compensation Electronics Assembly (RACE)

The RACE assembly converts digital RACE data from the DCC into an analog Earth rate signal, DIvk. RACE is used to compensate for the various effects of Earth's rate, depending on ship's geographic position. The DIvk signal represents the component of Earth rate about the local vertical. The DCC performs the digital computations that will yield an equivalent of DIvk and routes this digital equivalent of DIvk as RACE data to the RACE assembly in the ALNSS. The RACE assembly converts the RACE data into the analog DIvk signal, which is used in the fine alignment computations.

ERECTION SUBSYSTEM

ESS generates torquing signals that are used to position and maintain the missile stable platform v axis coincident with local vertical, establishing an Earth reference that serves as an inertial reference for the missile after launch. Local vertical corresponds to the direction of the greatest gravitational attraction.

The erection process is a missilized function and requires a separate erection loop for each of the 16 missiles. Each loop consists of two channels, r and j, that generate the signals used to torque the stable platform about its r and j axes, thereby erecting the v axis to the local vertical. The torquing signals are generated in response to error signals, representing the difference between the actual and desired platform orientation. An error in the orientation of the stable platform is detected by three accelerometers mounted on the inner gimbal of the guidance system. If the stable platform v axis is not erected, the accelerometers detect acceleration components that represent the magnitude and direction of the erection error. Because the accelerometers sense accelerations imparted to the missile by ship motion, as well as gravity, the Fire Control System must isolate the gravity components by subtracting ship motion accelerations from the erection error signal. The remaining gravity component is used to generate the torquing signal.

The erection error signal is proportional to the amount of miserection. As the stable platform is torqued to the desired position, the erection error signal decreases in magnitude. When the desired position is reached, the erection error signal is nulled. ESS maintains the stable platform at this position until platform disconnect.

Erection is accomplished in two operating modes, coarse and fine. These operating modes permit the erection of the v axis in minimal time. Each mode has a different loop gain and response time. The coarse mode has a high gain and fast response time to the error signal, and the fine loop mode has a lower gain and slower response time. The lower gain and slower response time permit the stable platform to be torqued at a reduced rate, thereby erecting it more accurately. Each ESS loop is divided into three assemblies, the digital erection assembly (DEA), the analog erection assembly (AEA), and a RACE assembly.

Digital Erection Assembly

The DEA receives accelerometer pulses from the missile guidance system, decodes the pulses into appropriate sr, sv, and j components, sums the individual components, and routes the result of the summation to the AEA.

The observed incremental missile accelerometer velocity outputs, oi(Ugm)s, are routed from the guidance system to the DEA (fig. 3-5). The oi(Ugm)s are generated in response to accelerations acting upon the missile and represent the magnitude and direction of miserection of the stable platform. The oi(Ugm)s are decoded in the DEA into the observed incremental accelerometer velocity along the sr, sv, and j axes, oi(Usrgm)s, oi(Usvgm)s, and oi(Ujgm)s signals. The oi(Usrgm)s and oi(Usvgm)s signals are routed to counter control circuits in the j channel, where they are algebraically summed, and the oi(Ujgm)s signal is routed to counter control circuits in the r channel.

The counter control circuits convert the incoming signals into add or subtract pulses, depending on the polarity of the signals. A positive signal results in an add pulse, and a negative signal results in a subtract pulse. Associated with each channel is a reversible counter that stores the add or subtract pulses. Each add pulse causes the reversible counter to count up one digit, and each subtract pulse causes the counter to count down one digit. Signals, representative of the stored count, are routed from the reversible counter in the DEA to the AEA as digital data.

Analog Erection Assembly

The AEA converts the digital data from the DEA into analog signals, corrects these signals for effects of missile motion, adds the Earth rate correction, and routes the resultant signals to the guidance system.

The digital data from the DEA, representing the miserection, is routed to digital-to-analog converters (DAC) in the AEA. The DACs convert the digital input to analog signals and route the analog signals to the series of amplifiers in the AEA.

The accelerometers that supply inputs to ESS are inertial devices and sense all acceleration imparted to the missile stable platform. However, in the erection process, only the accelerations caused by gravity are required to determine the erection error. The SGSS routes the missile linear launch velocity along the j and r axes, (Ujgm)k and (Urgm)k, to amplifiers in the AEA, where the signals are subtracted from the analog erection error signals to remove the effects of a moving ship from the erection computations.

Since the stable platform is erected to an Earth coordinate system and must remain fixed in this coordinate system, provisions must be made to compensate for the continuous rotation of the Earth. The RACE assembly routes the Earth angular velocity about the j axis, DIjk, to amplifiers in the AEA to be added to the analog erection error signals. Also, the SGSS routes the Earth angular velocity about the r axis, DIrk, to the AEA. The DIjk and DIrk signals cause the stable platform to be torqued in the same direction and at the same rate that the Earth rotates.

The outputs of the AEA are the erection torquing signals. When ESS is in the coarse mode, the outputs of the AEA are coarse erection torquing about the j and r axes, e(DAj) and e(DAr). In the fine mode, the outputs are fine erection torquing about the j and r axes, DAj and DAr signals. The AEA routes these signals to the missile guidance system to torque the stable platform to the desired position and to maintain the platform at this position until platform disconnect.

Rate Compensation Electronics Assembly

The RACE assembly controls the application of the DIjk signal. The DIjk signal is routed from the SGSS to the AEA via the RACE assembly. The RACE assembly is controlled by RACE data from the DCC.

MISSILE MOTION SUBSYSTEM

The missile motion subsystem is necessary primarily because of the movement of the ship and the missile during testing and launching sequences. We must remove the effects of acceleration of any nature imparted to the ship and the missile whether caused by environmental sources or the ship itself. In short, we must attempt to make the missile "think" it is being tested or launched from a stationary platform or site.

The MMSS calculates the motion imparted to each missile which is caused by the motion

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experienced by the ship. The MMSS continuously calculates missile launch velocities in the north, east, and vertical directions. When a missile becomes channelized, it calculates digital missile motion data in the slant horizontal, slant vertical, and cross-range directions. The MMSS is divided into two missile motion computers (MMC), each containing the necessary circuits to generate the desired missile motion quantities.

Generation of erection torquing signals and guidance data by the Fire Control System is performed under the assumption that the missiles will be launched from a stationary launch platform. When the missile stable platform is erected to the local vertical, the only desirable accelerations are the components of gravity. Since the accelerometers mounted on the missile stable platform detect submarine accelerations as well as gravity, some method for calculating the component of acceleration caused by the submarine motion is necessary. This task is performed by the MMSS. While the various guidance data are being compared by the DCC for a channelized missile, the MMSS is calculating the digital missile motion data to compensate for the initial velocity of the missile caused by ship motion. The MMSS accomplishes these calculations by converting ship motion, received from the navigation system, to motion imparted to each missile. This information is routed to the ESS, via the SGSS, as corrections to the erection torquing signals and to DRISS as corrections to the guidance data.

The MMSS performs various secondary functions necessary for the proper operation of fire control. To accomplish these functions, the MMSS generates and routes signals representing the difference between missile stable platform angles and SINS stable platform angles and routes signals representing launch bearing resolved about ship heading, and deck-tilt correction, which transfers missile misalignment from the deck plane to the horizontal plane, to the ALNSS.

Missile Motion Computer

There are three separate circuits comprising each MMC, the input circuit, the computing circuit, and the analog-to-digital converter (ADC)/interlace circuit.

The input circuit regenerates ship attitude and velocity signals from the navigation system, generates angular rate of pitch and heading signals, and performs resolutions to produce necessary quantities for the CSSS and ALNSS. The ship velocity and attitude signals from the navigation system are transmitted at various speeds. The degree of accuracy desired in fire control determines the speed of the resolver to be used in a particular computation.

The input circuits receive ship pitch (PI), ship roll (R), and ship heading (H) from the multispeed repeaters (MSR) in the navigation system (fig. 3-7) as Eio′, Zo, and Cqo′ respectively. The Eio′ and Cqo′ signals are used to develop the angular rate of pitch and heading signals, DEio′ and DCqo′, that are routed to the computing circuits. These signals are proportional to the rates at which the pitch and heading of the ship are changing. In addition, the input circuits use Eio′, Zo, and Cqo′ to position the input servos to the proper position so that the MMSS can perform its functions. The input circuit receives Byrg from SGSS and resolves it about Cqo′ to generate the quantity Byrg-Cqo′. The OAG routes Bdaim to the input circuit to be resolved about Zo, producing a quantity of deck tilt from the horizontal, Bdaim SIN^{2}Zo. Both of these resolution quantities are routed to the ALNSS. Eim and Zvm from the missile guidance system are resolved about Eio′ and Zo, respectively, to obtain the quantities Eim-Eio′ and Zvm-Zo. These values are routed to the CSSS to be used during the command slew process. The Cqo′ and Zo servo shafts are mechanically linked to respective resolvers in the computing circuit. These resolvers are used in the development of angular ship velocity signals.

The input circuit also receives, regenerates, and transmits ship velocity signals to the missile motion computing circuit for the development of missile motion data. The ship velocity signals east (VE), north (VN), and vertical (VV) are received from SINS in the navigation system as Uhxo, Uhyo, and Uvo and are routed to the computing circuit, where they are used in the generation of velocities imparted to the missiles.

Computing Circuit

The computing circuit generates an angular ship velocity east signal, Wxo; an angular ship velocity north signal, Wyo; an eastward missile linear launch velocity signal, Uhxgm; a northward missile linear launch velocity signal, Uhygm; and a vertical linear launch velocity signal, (Uvgm)k.

All ship velocities are measured at SINS. It is possible, therefore, for the velocities measured at SINS to be relatively low, while the velocities felt by the missile are relatively high, specifically during rapid pitching of the ship. The farther a missile is located from SINS, the greater the effect of the ship velocities on the missile. Because the missiles are located at various distances from SINS, these effects must be considered. These distances are added to the missile motions computations in the form of constants and are called lever arms. The computing circuit multiplies the SINS measured velocities by the appropriate lever arm values to determine the velocities felt by the missile.

To generate Wxo and Wyo, the computing circuit uses the DCqo′, DEio′, and Zo signals from the input circuit. The computing circuit resolves DCqo′ about Cqo′ and DEio′ about Zo and Cqo′. The results of these resolutions are summed to produce Wxo and Wyo. Signal Wxo is used in the computing circuit for additional computations and is also routed to the ADC/interlace circuit of MMC1. Signal Wyo is also used by the computing circuit for additional computations and routed to the ADC/interlace circuit of MMC2.

To generate Uhxgm and Uhygm, the computing circuit sums signals Wxo with Uhxo and Wyo with Uhyo. To these summations the computing circuits add the appropriate lever arm values. The results of these summations are the Uhxgm and Uhygm signals. However, these signals are ship-oriented and can not be used by the missile. To convert the ship-oriented signals into missile-oriented signals, the signals must be resolved about Byrg. The Uhxgm and Uhygm signals are routed to the SGSS, where they are resolved about Byrg, resulting in the (Urgm)k and (Ujgm)k signals. These signals are then routed to the ADC/interlace circuit in the MMSS and are also routed to the erection subsystem. The Uhxgm and Uhygm signals are also used to compare the operation of the two MMCs. Signal Uhxgm is routed to the ADC/interlace circuit of MMC1, and signal Uhygm is routed to the ADC/interlace circuit of MMC2.

The computing circuit generates the (Uvgm)k signal by summing the Uvo and DEio′ signals from the input circuit and adding the appropriate lever arm. The (Uvgm)k signal needs no further resolution because the vertical component references for both the ship and missile are the same.

Analog-to-Digital Converter/Interlace Circuit

The ADC/interlace circuit generates, multiplexes, and routes missile motion data in the guidance computing coordinate axes for each missile as it is assigned to channel. The analog quantities, (Urgm)k and (Ujgm)k from the SGSS and (Uvgm)k from the computing circuit, are placed in the guidance computing coordinate axes because the guidance computer performs its calculations in these axes. The guidance computer operates in these axes because the accelerometers which sense accelerations after launch are physically mounted on the slant horizontal range (sr), slant vertical (sv), and crossrange (j) axes of the gimbal assembly. To place the analog quantities in the guidance computing coordinate axes, the ADC/interlace circuit combines the positive and negative components of (Urgm)k and (Uvgm)k. The results of these summations are converted to digital form and routed to the interlace portion of the ADC/interlace circuit as (Usrgm)k and (Usvgm)k. In addition, the (Ujgm)k signal is converted from analog to digital form and routed to the interlace portion. These data are then multiplexed onto a time-shared transmission line and routed to DRISS.

The ADC/interlace circuit provides an additional function prior to the missile being channelized. The Uhxgm and Wxo signals from the computing circuits in MMC1 are compared with the Uhxgm and Wxo signals from MMC2. If these quantities are not within specified limits, an alarm is generated and routed to the control console. The Uhygm and Wyo signals from the computing circuits of MMC1 are routed to MMC2 for a similar comparison. These comparisons ensure that the two MMCs are computing data that are equal in magnitude but opposite in polarity.

SERVO GROUP SUBSYSTEM

The SGSS, (fig. 3-7) provides velocity, position, and bearing data to the various fire control subsystems to enable their functions in preparation of the POSEIDON missile for launch. Inputs and outputs of the SGSS have been described several times in the text; however, this section should help tie the subsystem together for you. The SGSS consists of input servo assemblies, output servo assemblies, and input and output multiplexers. The input servo assemblies contain Cqo', ship's latitude, Lyo, and ship's longitude, Lxo, servos. The output servo assemblies consist of coarse and fine Byrg servos.

Input Servo Assemblies

The input servo assemblies provide position data to the DCC and bearing and velocity data to the output servo assemblies.

In order to provide the position data to the DCC (fig. 3-7) the Lyo and Lxo servos receive latitude, L, and longitude, LO, from SINS in the navigation system as Lyo and Lxo, respectively. These inputs position the servo shafts the outputs of which are converted to digital format and routed to the DCC.

The bearing and velocity data to the output servo assemblies are provided by the Cqo' servo, which combines Cqo' from the MSR in the navigation system with Cqhm received as Bmr from the missile, and routes Cqo'+Bmr to the output servo assemblies to provide components of the coarse alignment signal for the ALNSS. The velocity data are provided by the DIyk component of Earth rate that is routed to the output servo assemblies for further resolution.

Output Servo Assemblies

The output servo assemblies provide velocity data to ESS, velocity and bearing data to the MMSS, and bearing data to the ALNSS and CSSS. Each Byrg servo in the output servo assemblies is positioned by a Byrg input from the DCC. The position of the Byrg servo is routed back to the DCC as a Byrg position signal to enable the DCC to update its computation of Byrg.

In order to provide the velocity data to the ESS, the output servo assemblies receive Uhxgm and Uhygm from the MMSS. The Uhxgm value is resolved about Byrg to generate (Urgm)k. Similar calculations are performed on Uhygm, yielding (Ujgm)k. The (Urgm)k and (Ujgm)k signals are routed to ESS and to the ADC/interlace circuits in the MMSS.

The remainder of the velocity data for ESS is generated by the output servos by resolving DIyk from the input servo about Byrg. This resolution results in DIrk and DIjk, which are routed to the erection subsystem. The bearing data to the MMSS are routed from the Byrg servo as Byrg to the input circuits of each MMC in the MMSS.

The bearing data for the ALNSS and CSSS are generated by resolving Bmr+Cqo' from the input servo assemblies and Cqo' from the MSR about Byrg. These two resolutions yield Byrg-Cqo'-Bmr and Byrg-Cqo'. The Byrg-Cqo'-Bmr signal is routed to the ALNSS for use in generating the coarse alignment torquing signal and to CSSS for use in generating the inner gimbal command slew signal. The Byrg-Cqo' signal is routed to the ALNSS to provide components of the fine alignment torquing signals.

Input and Output Multiplexers

Under control of the DCC, the input and output multiplexers act as gating devices for the transfer of data between the DCC and the input servo assemblies, output servo assemblies, and the DCC peripheral equipment.

The input multiplexer controls the readin of data to the DCC from the input and output servo assemblies and DCC peripheral equipment in a predetermined sequence. A control signal from the DCC initiates operation of the multiplexer. Upon activation, the multiplexer routes an enable signal to the first equipment that will read in data to the DCC. The multiplexer sequences through the input equipment, selecting each in turn and enabling it to read data into the DCC. After all data are read into the DCC, the multiplexer stops its sequence until the next control signal is received from the DCC.

The output multiplexers operate in a manner similar to the input multiplexers, except the enable signals allow the equipment to receive data from the DCC rather than transmit data to the DCC.

DIGITAL CONTROL COMPUTER GROUP

The DCC group computes guidance quantities, launch bearing, and fuze set data for all 16 POSEIDON missiles. These data are utilized by the ALNSS, DRISS, and FSSS to align the missile stable platform, provide the missile guidance computer with the data necessary to compute a missile trajectory to impact the target, and provide the missile with the data necessary to arm the reentry bodies. The DCC group consists of two DCCs and DCC peripheral equipment. The DCCs and DCC peripheral equipment interact to perform the DCC group operations. Chapter 4 describes the DCC in detail.

Digital Control Computer

The DCC performs all the necessary calculations to produce launch bearing, fuze set, and guidance data for 16 POSEIDON missiles. The DCC also computes RACE data for the ALNSS and ESS. The DCC is a high-speed, general purpose computer that has been adapted to perform the arithmetic calculations for the Fire Control System. Because of the high speed, parallel operation of the DCC, in comparison to the slower speed of the serial equipment in the remainder of fire control, numerous units of peripheral equipment are necessary to transfer data to and from the DCC.

To increase system reliability, there are two DCCs, each capable of supplying the necessary data for all 16 missiles. Under normal conditions, DCC1 will be connected to channel 1 and supply data for missiles 1 through 8, and DCC2 will be connected to channel 2 and supply data for missiles 9 through 16. Since DCC1 and DCC2 are identical, only one DCC will be discussed. The DCC is comprised of four sections: memory, arithmetic, control and input/output (I/O).

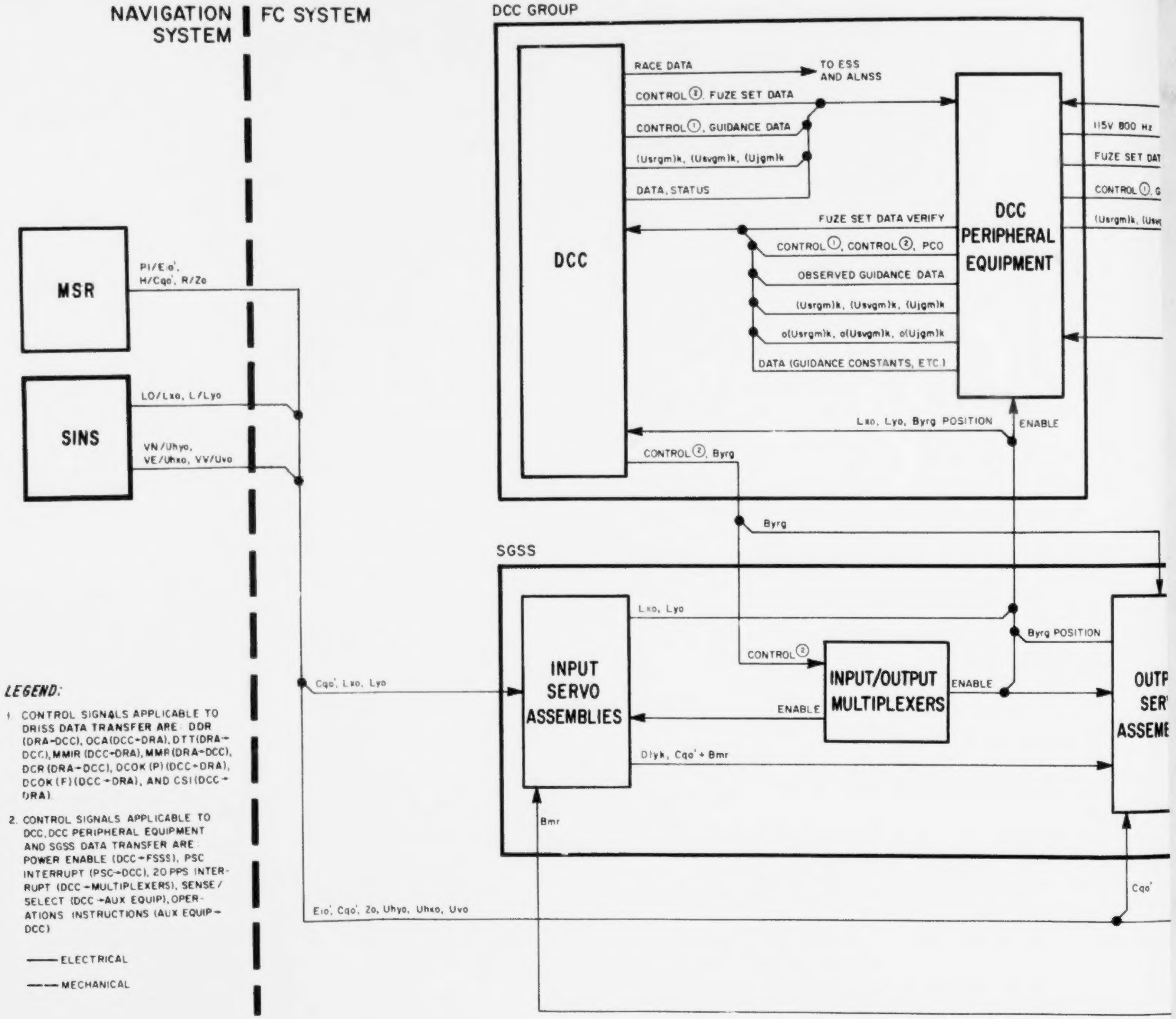
The memory section is a magnetic core memory device that provides access to approximately 16,000 24-bit words. These 24-bit words are either informative data, a computer instruction, or a combination of both. The arithmetic section performs the basic mathematical processes of addition, subtraction, multiplication, and division required by the computer. The control section initiates the proper sequence of events to perform the various computer instructions and controls the flow of data between sections of the DCC. The I/O section provides interface between the DCC and equipment external to the DCC. The I/O section is divided into eight channels. Four channels receive the necessary input data from fc, and four channels supply the DCC outputs to fire control.

Digital Control Computer Peripheral Equipment

The DCC peripheral equipment provides a communications link between the DCC and other components of the weapon system. The DCC peripheral equipment consists of the fuze set subsystem (FSSS), the parallel to serial converter (PSC), events translator (ET), keyboard, printer, tape reader, magnetic disk file (MDF), and intercomputer link (ICL).

FSSS.–The FSSS provides an interface between the DCC and the command sequencer in the missile electrical subsystem. The FSSS transfers fuze set data between the DCC and missiles.

PSC.–The PSC enables transmission between the DCC and DRISS. DRISS is a serial device that receives and transmits data one bit at a time, while the DCC is a parallel device that receives and transmits data one 24-bit word at a time. The PSC accomplishes the necessary


NAVIGATION SYSTEM
FC SYSTEM
MSR
PI/Eio',
H/Cqo', R/Zo
SINS
LO/Lxo, L/Lyo
VN/Uhyo,
VE/Uhxo, VV/Uvo
DCC GROUP
DCC
RACE DATA
TO ESS
AND ALNSS
CONTROL ②, FUZE SET DATA
CONTROL ①, GUIDANCE DATA
(Usrgm)k, (Usvgm)k, (Ujgm)k
DATA, STATUS
FUZE SET DATA VERIFY
CONTROL ①, CONTROL ②, PCO
OBSERVED GUIDANCE DATA
(Usrgm)k, (Usvgm)k, (Ujgm)k
o(Usrgm)k, o(Usvgm)k, o(Ujgm)k
DATA (GUIDANCE CONSTANTS, ETC.)
DCC
PERIPHERAL
EQUIPMENT
115V 800 Hz
FUZE SET DAT
CONTROL ①, G
(Usrgm)k, (Usv
Lxo, Lyo, Byrg POSITION
ENABLE
CONTROL ②, Byrg
Byrg
SGSS
INPUT
SERVO
ASSEMBLIES
Cqo', Lxo, Lyo
Lxo, Lyo
CONTROL ②
INPUT/OUTPUT
MULTIPLEXERS
ENABLE
ENABLE
Byrg POSITION
Dlyk, Cqo' + Bmr
OUTP
SER
ASSEME
Bmr
Cqo'
Eio', Cqo', Zo, Uhyo, Uhxo, Uvo

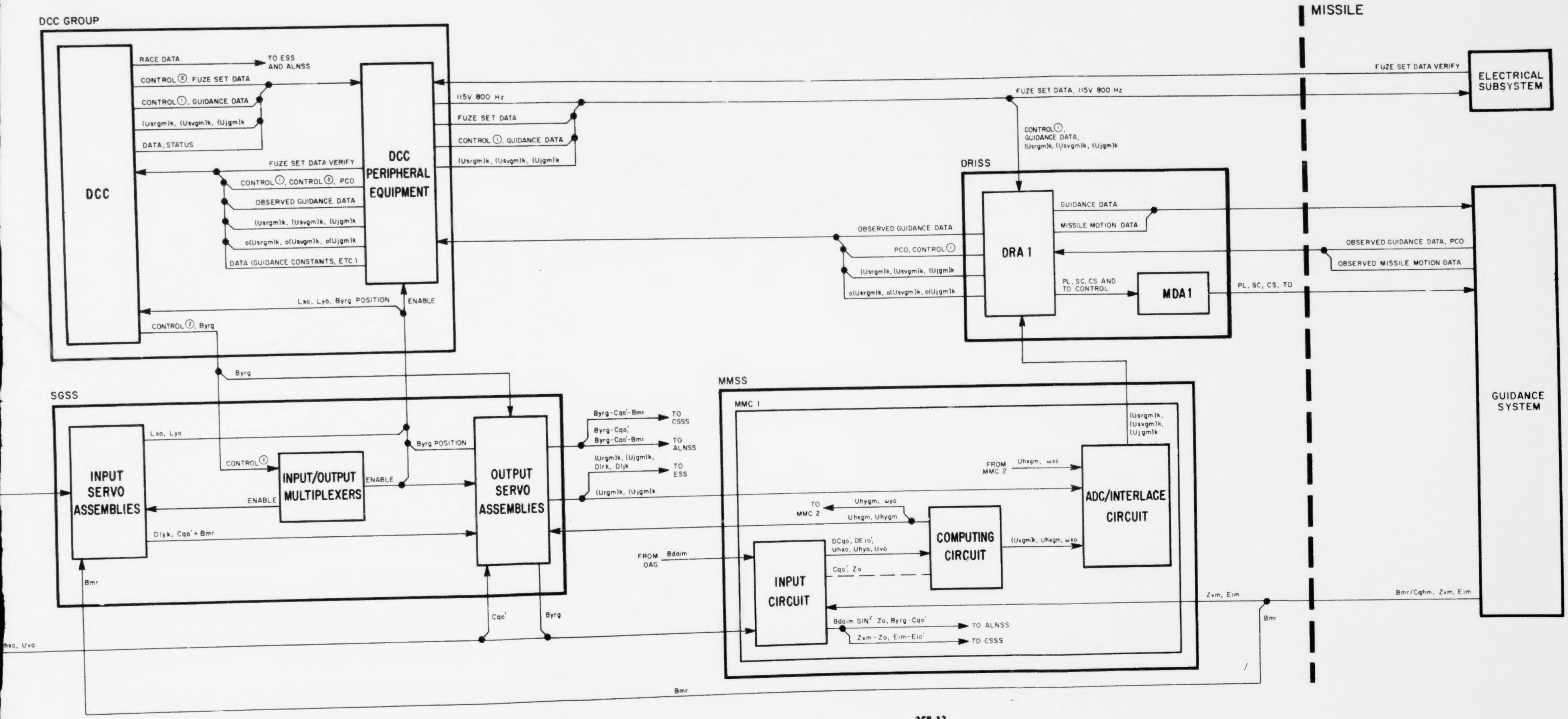
LEGEND:

1. CONTROL SIGNALS APPLICABLE TO DRISS DATA TRANSFER ARE: DDR (DRA→DCC), OCA(DCC→DRA), DTT(DRA→DCC), MMIR (DCC→DRA), MMR (DRA→DCC), DCR (DRA→DCC), DCOK (P) (DCC→DRA), DCOK (F) (DCC→DRA), AND CSI (DCC→DRA).
2. CONTROL SIGNALS APPLICABLE TO DCC, DCC PERIPHERAL EQUIPMENT AND SGSS DATA TRANSFER ARE: POWER ENABLE (DCC→FSSS), PSC INTERRUPT (PSC→DCC), 20 PPS INTERRUPT (DCC→MULTIPLEXERS), SENSE/SELECT (DCC→AUX EQUIP), OPERATIONS INSTRUCTIONS (AUX EQUIP→DCC)

—— ELECTRICAL

– – – MECHANICAL

Figure 3-7.—Digital Control Com


DCC GROUP
DCC
RACE DATA
TO ESS AND ALNSS
CONTROL ②, FUZE SET DATA
CONTROL ①, GUIDANCE DATA
(Usrgm)k, (Usvgm)k, (Ujgm)k
DATA, STATUS
FUZE SET DATA VERIFY
CONTROL ①, CONTROL ②, PCO
OBSERVED GUIDANCE DATA
(Usrgm)k, (Usvgm)k, (Ujgm)k
o(Usrgm)k, o(Usvgm)k, o(Ujgm)k
DATA (GUIDANCE CONSTANTS, ETC.)
DCC PERIPHERAL EQUIPMENT
115V 800 Hz
FUZE SET DATA
CONTROL ①, GUIDANCE DATA
(Usrgm)k, (Usvgm)k, (Ujgm)k
Lxo, Lyo, Byrg POSITION
ENABLE
CONTROL ②, Byrg
Byrg
MISSILE
FUZE SET DATA VERIFY
ELECTRICAL SUBSYSTEM
FUZE SET DATA, 115V 800 Hz
CONTROL ①, GUIDANCE DATA, (Usrgm)k, (Usvgm)k, (Ujgm)k
DRISS
DRA 1
GUIDANCE DATA
MISSILE MOTION DATA
OBSERVED GUIDANCE DATA
PCO, CONTROL ①
(Usrgm)k, (Usvgm)k, (Ujgm)k
o(Usrgm)k, o(Usvgm)k, o(Ujgm)k
PL, SC, CS AND TO CONTROL
MDA 1
PL, SC, CS, TO
OBSERVED GUIDANCE DATA, PCO
OBSERVED MISSILE MOTION DATA
GUIDANCE SYSTEM
SGSS
INPUT SERVO ASSEMBLIES
Lxo, Lyo
CONTROL ②
INPUT/OUTPUT MULTIPLEXERS
ENABLE
ENABLE
Byrg POSITION
OUTPUT SERVO ASSEMBLIES
Dlyk, Cqo' + Bmr
Byrg-Cqo'-Bmr
TO CSSS
Byrg-Cqo', Byrg-Cqo'-Bmr
TO ALNSS
(Urgm)k, (Ujgm)k, Dlrk, Dljk
TO ESS
(Urgm)k, (Ujgm)k
Bmr
Cqo'
Byrg
hxo, Uvo
MMSS
MMC 1
(Usrgm)k, (Usvgm)k, (Ujgm)k
FROM MMC 2
Uhxgm, ωxc
ADC/INTERLACE CIRCUIT
TO MMC 2
Uhygm, ωyo
Uhxgm, Uhygm
COMPUTING CIRCUIT
(Uvgm)k, Uhxgm, ωxo
DCqo', DEιo', Uhxo, Uhyo, Uvo
FROM OAG
Bdaim
INPUT CIRCUIT
Cqo', Zo
Zvm, Eim
Bmr/Cqhm, Zvm, Eim
Bmr
Bdaim SIN² Zo, Byrg-Cqo'
TO ALNSS
Zvm-Zo, Eim-Eιo'
TO CSSS
Bmr

258.13

Figure 3-7.—Digital Control Computer Group, Servo Group Subsystem Missile Motion Subsystem, and Digital Readin Subsystem Data Flow.

change in format (serial-to-parallel and parallel-to-serial) for those two devices to communicate with each other.

ET.–The ET provides a transfer path for control, status, and assignment data from CDSS to the DCC and for missile identification and fuze set status data from the DCC to CDSS. The control, status, and assignment data are used by the DCC to modify its computations. The missile identification and fuze set status data are used by CDSS to aid in controlling the fire control operation.

KEYBOARD.–The keyboard enables communications between the DCC operator and the DCC. The operator uses the keyboard to enter data and control signals into the DCC. The data consists of target and wind offsets, missile to target assignments, etc. The control signals consist of operation instructions for the DCC. After data is read into the DCC from the keyboard, it is routed back to the display portion of the keyboard for the fire control operator's verification.

PRINTER.–The printer provides a permanent record of alarms and specific commanded printouts from the DCCs. The printer prints out alarm information automatically and specific DCC storage data on command from the keyboard. Commanded printouts consist of status information concerning the missile and Fire Control System.

TAPE READER.–The tape reader enters guidance constants into the DCC. Prior to a patrol, a perforated Mylar tape containing the specific constants for each guidance system is placed in the tape reader. The tape reader decodes the tape and reads the constants into an MDF via the DCC.

MDF.–The MDF is a mass storage device that supplements the core memory of the DCC. There are two MDFs, one for each DCC, each with a storage capacity of approximately two million 24-bit words. Each MDF is preprogrammed with all tactical programs, test programs, maintenance programs, and target data. The MDF also contains guidance system constants that were inserted via the tape reader and the DCC.

ICL.–The ICL transfers data, in parallel form, between the two DCCs.

Digital Control Computer Group

The DCC group generates launch bearing data, fuze set data, and guidance data. In addition, the DCC generates a program checkout (PCO) word to verify the proper operation of the guidance computer and provides RACE data that are used during stable platform orientation. Various control signals are necessary for proper communication with DRISS for the guidance quantities, with SGSS for launch bearing data, and with DCC peripheral equipment for fuze set and tactical target data. The DCC routes control signals to the SGSS input and output multiplexers to generate enable signals that permit the various fire control equipment to accept data from or route data to the DCC.

LAUNCH BEARING DATA.–Prior to a missile being channelized, the DCC (fig. 3-7) receives Lyo and Lxo from the SGSS. These data are used by the DCC in combination with stored target parameters to compute a digital representation of Byrg. The DCC compares this digital representation of Byrg with the stored sector plan and selects a particular alignment segment. The DCC then selects the sector Byrg within the alignment segment and, upon receipt of the enable signal from the output multiplexer, routes the sector Byrg to the SGSS output servo assemblies to position the coarse Byrg servos. The DCC must know the current position of the coarse Byrg servos in order to compute the error signal to update their position. This Byrg position signal is read into the DCC from the output servo assemblies upon receipt of an enable signal from the input multiplexer.

FUZE SET DATA.–After a missile is channelized and upon receipt of a digital data request (DDR) control signal from DRISS, the PSC generates and routes a control signal to the DCC. This control signal interrupts the DCC program, causing the DCC to compute the fuze set data and transmit a power enable control signal to the FSSS. The FSSS, in turn, routes 115 V, 800 Hz power to the command sequencer in the missile electrical subsystem. Approximately 200 milliseconds after power is applied to the command sequencer, the fuze set data are routed in parallel format from the DCC to the FSSS. The FSSS is controlled by an enable signal from the SGSS output multiplexer. The FSSS receives the fuze set data, converts it to serial format and routes the data to the command sequencer.

After the command sequencer has received the fuze set data, it returns the fuze set data as fuze set data verify to the FSSS. As fuze set data verify is returned to the FSSS, an enable signal from the SGSS input multiplexer to the FSSS allows fuze set data verify to be routed to the DCC. When the last fuze set data verify signal is returned, the DCC performs a bit-for-bit comparison to ensure accurate data transmission.

GUIDANCE QUANTITY GENERATION.–Upon completion of fuze set, the DCC generates the guidance data words. The guidance data words consist of tactical offsets, wind-over-target offsets, various information peculiar to the guidance system such as gyro drift data, and steering instructions (used to compensate for the difference between target Byrg and sector Byrg). The guidance data words are routed in parallel format to the PSC. The PSC converts the guidance data to serial format and transmits them to DRISS. The DCC also uses ship latitude to determine the Earth rate correction about local vertical. The result of this computation is routed to the ALNSS as part of the RACE data. The DCC computes additional RACE data that are routed to ESS to either enable or inhibit the application of the j Earth rate component from SGSS.

After the guidance data have been received by DRISS, they are routed by DRISS to the guidance computer in the missile. The guidance computer returns the guidance data to DRISS as observed guidance data to the DCC, via the PSC, for comparison with the originally transmitted data to ensure accurate data transmission.

The DCC then routes a missile motion input request (MMIR) control signal to DRISS via the PSC. DRISS routes the missile motion data words (Usrgm)k, (Usvgm)k and (Ujgm)k to the PSC, where the data are converted into parallel format and routed to the DCC. The DCC converts the data from a 17-bit format to a 24-bit format acceptable to the guidance computer.

Upon receipt of a missile motion request (MMR) control signal from DRISS, the PSC generates a control signal to the DCC that interrupts the DCC program and causes the DCC to transmit the missile motion data to DRISS via the PSC. DRISS then routes the data to the guidance computer, and the transmission of observed missile motion data back to the DCC is accomplished in a manner similar to that described in the transmission of guidance data.

After all missile motion and guidance data have been transmitted from and to the DCC, the missile guidance computer generates and routes the PCO word to the DCC via DRISS and the PSC. The PSC receives a data check request (DCR) control signal from DRISS and generates a control signal to the DCC. This control signal causes the DCC to compute its own PCO word and compare it with the one from the guidance computer, ensuring that accurate computations were performed in the guidance computer. At completion of this comparison, a data-check-OK (DCOK) control signal is generated and routed to DRISS, indicating that the guidance data transmission is complete.

There are two DCOK control signals, DCOK(P) and DCOK(F). DCOK(P) is generated after the guidance initialization sequence, and DCOK(F) is generated during the fire sequence. Each indicates that the respective guidance data transmission is complete.

Digital Readin Subsystem

DRISS provides a controlled interface between the digital subsystems of the Fire Control System and the missile guidance system. DRISS controls the transfer of guidance and missile motion data between the DCC and the guidance system computer. DRISS also controls the transfer of digital missile motion between the MMSS and the DCC. In addition, DRISS generates and routes guidance computer control signals necessary for the proper operation of the guidance computer in each missile.

Because the DCC and guidance computer are relatively high-speed, parallel-operating computers, and the interface between the computers operates in serial format, the data being transferred between the computers must be scheduled to occur coincidentally with other necessary operations. Therefore, the DRISS controlled data readin occurs during specific sequences. The sequences are guidance initialization and fire.

DRISS GUIDANCE INITIALIZATION SEQUENCE.–The guidance initialization sequence is automatically enabled immediately after gyro spinup. Each missile is assigned to a channel in accordance with the missile-to-fire order patch panel on the control console. The guidance initialization sequence consists of a DRISS data transfer sequence and command slewing of the guidance system gimbals to their approximate aligned and erected position. The data transfer is necessary to check the operation of DRISS and the guidance computer prior to switching the missile to internal power. Basically, the data transfer assembles all the guidance and missile motion data in the DCC, controls the transfer of these data to the guidance computer, and transfers the observed guidance data and PCO word from the guidance computer to the DCC. Successful completion of the guidance initialization sequence indicates that all guidance system gimbals have nulled, and the data transfer is successful.

DRISS FIRE SEQUENCE.–The fire sequence is the final readin, readout, and check of the guidance data that verifies proper guidance computer operation and the readin and check of the fuze set data. This process places the guidance presets (corrected to estimated time of launch and ship location) into the guidance computer and sets the fuzes to the proper detonation points. The fire sequence begins after the missile has been switched to internal power and consists of essentially the same process as the guidance initialization sequence except for the addition of the fuze set data.

DRISS consists of two digital readin assemblies (DRA) and two missilized driver assemblies (MDA). Either DRA can supply control signals to either MDA, but only the interaction between DRA1 and MDA1 will be described.

DIGITAL READIN ASSEMBLY.–The DRA controls the transfer of digital information between the DCC and the guidance system of a channelized missile. In addition, the DRA controls the generation of guidance computer control signals by the MDA and generates fire control signals. Transfer of data within fire control is accomplished by multiplexing information onto one transmission line and gating the data by the use of timing signals from MCTSS. All data transferred between DRISS and DCC is always via the PSC, but to simplify this discussion, the PSC is excluded. Data transfer between DRISS and the guidance system is accomplished in a different manner.

The transfer of digital information between DRISS and the guidance computer is accomplished on six transmission lines. The transmission lines are divided into two sets, each containing a logic 1, logic 0, and strobe line. Each set is identified by the transmitting source; that is, if data are transferred from fire control to the guidance computer, they are transferred on the fire control logic lines; and if data are transferred to fire control from the guidance computer, they are transferred on the guidance logic lines. The logic 1 and logic 0 transmission lines are used to transfer data pulses; the strobe line carries pulses only when data are present on the other lines.

The generation of guidance computer control signals is accomplished by the MDA, under control of the DRA. The guidance computer control signals are necessary to enable the guidance computer to perform its functions properly and sequentially with events occurring in fire control. The signals routed to the MDA are phase lock (PL), clock synchronization (CS), start computer (SC), and time zero (TO) control.

MISSILIZED DRIVER ASSEMBLY.–The MDA generates and routes guidance computer control signals PL, CS, SC, and TO to the associated missiles. Signals PL and CS synchronize fire control and guidance system timing. PL synchronizes guidance system 800 Hz signals with fire control 800 Hz signals, and CS synchronizes the guidance system clock with the fire control clock. PL is continuously generated from the time a missile is assigned to a channel until the generation of TO during the launch state or DRISS fire sequence. CS is continuously generated from the time a missile is assigned to a channel until a clock-synchronization-inhibit (CSI) signal is generated by the DCC. The CSI signal is routed to the DRA, which in turn inhibits CS generation by the MDA. This is accomplished only during the launch state or fire sequence and enables the guidance computer clock to become free-running after the guidance computer PCO word has been routed to fire control.

The SC signal causes the guidance computer to start computations on data received from fire control. The SC control signal from DRA causes the generation of SC by the MDA. When generated prior to TO, the SC signal enables the guidance computer to execute its tactical program.

The TO signal prevents further readin of data from fire control during any sequence. Upon the receipt of TO, the guidance system generates the guidance computer PCO word and routes it to fire control. During the fire sequence, TO allows the guidance system gimbal assembly to become inertially referenced by disconnecting the stable platform from fire control inputs and unconditionally causes the generation of SC in the guidance computer.

The occurrence of the DCOK control signal at the completion of the fire sequence completes DRISS operations, but SC, TO, and CSI are maintained until the missile is launched.

DIGITAL DATA TRANSMISSION.–DRISS transmits data to each missile after the missile has been assigned to a fire control channel. The data transmission occurs in three distinct parts: guidance data readin, missile motion readin, and data check.

Guidance Data Readin.–When a missile is assigned to channel, the DRA routes a DDR control signal (fig. 3-7) to the DCC, enabling the DCC to compute and assemble the guidance data words. When this is complete, an output channel active (OCA) control signal is routed from the DCC to the DRA, indicating that the guidance data are assembled and ready to be routed to the guidance system. To identify the data words generated by the DCC, the DRA generates digital transfer timing (DTT) control signals. Following the OCA signal, the first guidance data word, which is identified by the first DTT signal, is routed to the guidance system. The remaining guidance data words are transferred in a similar manner, and upon completion of this transfer, the DRA generates the SC control signal and routes it to the MDA. The MDA uses the SC control signal to generate and route the SC signal to the guidance computer.

Upon receipt of SC, the guidance computer begins its computations on the data received from fire control and routes the observed guidance data words back to the DCC via the DRA. The DRA is alerted to the readback of guidance data by the occurrence of the first guidance strobe pulse coincident with the first guidance data bit. At this time, the DRA generates DTT signals to identify the returning information for the DCC. When readback is complete, the DRA detects a loss of guidance strobe pulse, and the DCC begins a bit-for-bit comparison of the transmitted and received data. This comparison is made to ensure proper transmission of the guidance data. If the comparison is satisfactory, the DCC routes a control signal to the DRA, inhibiting the SC control signal, which, in turn, causes the MDA to stop generation of the SC signal. Approximately 700 milliseconds after the OCA signal is generated, the DCC routes an MMIR control signal to the DRA, initiating the readin of the missile motion quantities to the DCC.

Missile Motion Readin.–The MMIR control signal requests the DRA to route (Usrgm)k, (Usvgm)k and (Ujgm)k to the DCC. As the last missile motion data word is received in the DCC, DRA generates and routes an MMR control signal to the DCC. The DCC converts the 17-bit missile motion data words into 24-bit format and routes them to the guidance computer in the same manner as the guidance data.

Readback of the observed missile motion data is accomplished by the guidance computer without the SC signal from the MDA (SC is not necessary for less than 64 data words). As o(Usrgm)k, o(Usvgm)k and o(Ujgm)k are routed through the DRA to the DCC, the second loss of guidance strobe causes the DRA to generate and route the TO control signal to the appropriate MDA. The MDA generates and routes TO to the guidance system, which allows the guidance computer to generate a PCO word, thus starting the data check operation.

Data Check.—The data check is performed when a second MMIR is generated by the DCC. The missile motion data received from DRISS at this time are used to generate a DCC PCO word, but the data are not routed to the guidance computer. The missile motion data are used to ensure that the motion of the ship is not in excess of required firing limits stored in the DCC. The PCO word generated in the guidance computer is routed to the DCC via the DRA and compared with the DCC PCO word. The comparison is enabled by a DCR control signal generated by the DRA and routed to the DCC when the third loss of guidance strobe occurs. If the PCO words compare within specified limits, a DCOK (P) or (F) control signal is generated by the DCC and routed to the DRA. During the guidance initialization sequence, the DCOK(P) signal causes DRISS to route a DRISS-prepared signal to the CDSS, and the DCOK(F) signal causes DRISS to route a DRISS-intent-to-fire signal to CDSS. The signals notify CDSS that DRISS has successfully completed the respective sequences.

The guidance data readin, missile motion readin, and data check operations are performed in a similar manner during both the guidance initialization and fire sequences.

Modular Locations

In discussing the Fire Control System, it was noted that the majority of the system and subsystems are located in the Missile Control Center. As an FTB, you must know how to locate the subsystems, and, even more of a breakdown, a particular component or module of a subsystem. The Mk 88 POSEIDON Fire Control System uses a unique reference designation system to locate these subsystems and modules within the system. Figure 3-8 shows the components of the Fire Control System located in MCC. Notice that most of the equipment is labeled with numbers, such as 050, 052, etc. These numbers partially describe a major location that may be further broken down in the system by the addition of numbers and letters to identify the exact location of a particular module anywhere in the system. This is extremely valuable to know in order that you may assist in troubleshooting a casualty or conducting preventative maintenance.

If you were conducting a test and a diagnostic routine indicated that you had a faulty relay located at reference designation 050B18D34RA, it would be relatively simple to locate this relay module with a minimum amount of time following the guide given here.

050 is the major door mounted assembly.

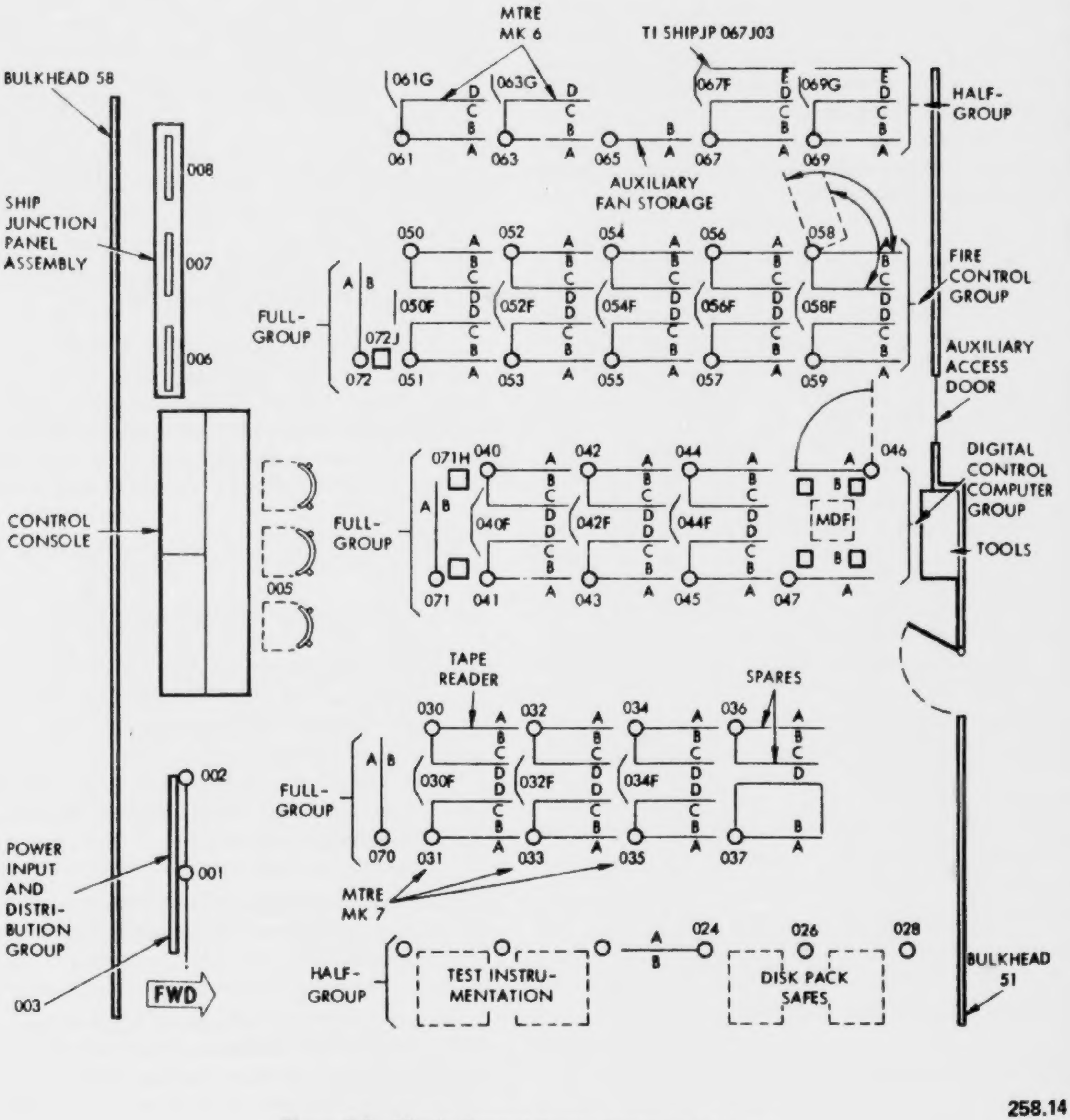
B is the door face designator indicating that the module is located on the inside of the first swing-out door. A indicates the front of the door. C indicates the front of the second swing-out door, etc.

18 is the door row that corresponds to the top of the appropriate subsystem assembly of modules.

D is the specific row of modules (the fourth row down from the top of the subsystem assembly).

34 is the vertical column of locator pins on the D row, numbered from left to right, that the individual module plugs into.

RA is the key code identifier of the faulty module located at the identified designation.


MTRE MK 6
TI SHIPJP 067J03
BULKHEAD 58
HALF-GROUP
061G
063G
067F
069G
061
063
065
067
069
AUXILIARY FAN STORAGE
008
007
006
SHIP JUNCTION PANEL ASSEMBLY
050
052
054
056
058
FIRE CONTROL GROUP
FULL-GROUP
050F
052F
054F
056F
058F
072J
072
051
053
055
057
059
AUXILIARY ACCESS DOOR
071H
040
042
044
046
DIGITAL CONTROL COMPUTER GROUP
CONTROL CONSOLE
040F
042F
044F
MDF
TOOLS
005
071
041
043
045
047
TAPE READER
SPARES
030
032
034
036
030F
032F
034F
070
031
033
035
037
002
001
POWER INPUT AND DISTRIBUTION GROUP
MTRE MK 7
024
026
028
TEST INSTRUMENTATION
DISK PACK SAFES
BULKHEAD 51
003
FWD

258.14

Figure 3-8.—Missile Control Center Equipment Layout.

With a little practice, you will be able to quickly locate a module anyplace in the system.

If you have questions concerning interface of various signals or functions of the various subsystems of the Fire Control System, chapter 5, POSEIDON Weapon System Operation, will tie all these together in a simulated Battle Stations Missile configuration. First, however, you must have a good knowledge of the DGBC and the MDF that are covered in the next chapter.

CHAPTER 4

DIGITAL GEO-BALLISTIC COMPUTER AND MAGNETIC DISK FILE

The Digital Geo-Ballistic Computer (DGBC) is a general purpose computer adapted to function as an integral part of the Mk 88 Fire Control System and the Mk 113 Torpedo Fire Control System. The primary purpose of the DGBC is to perform prelaunch calculations for the POSEIDON weapon system and calculations for the Mk 113 Torpedo Fire Control System. Fire control quantities and missile quantities discussed in the previous chapters, plus certain static and dynamic quantities, are computed to accurately deliver the missile reentry bodies to the proper impact point of selected targets. The DGBC also aids in tests and evaluations of the fire control and missile subsystems.

The DGBC is comprised of two Digital Control Computers (DCC), two Magnetic Disk Files (MDF), a fire control-DGBC interface, and an operator interface.

The Mk 88 FCS DGBC contains two DCCs for continued missile firing rate in the event one malfunctions. Both units operate identically; therefore, only one DCC will be referred to in this text. The DCC performs the digital calculations for the POSEIDON FCS and the Mk 113 Torpedo FCS. In doing this, the DCC interfaces with other elements of the FCS. Figure 4-1 illustrates the relationships between the DCC and the remainder of the POSEIDON fire control system.

DCC FUNCTIONAL DESCRIPTION

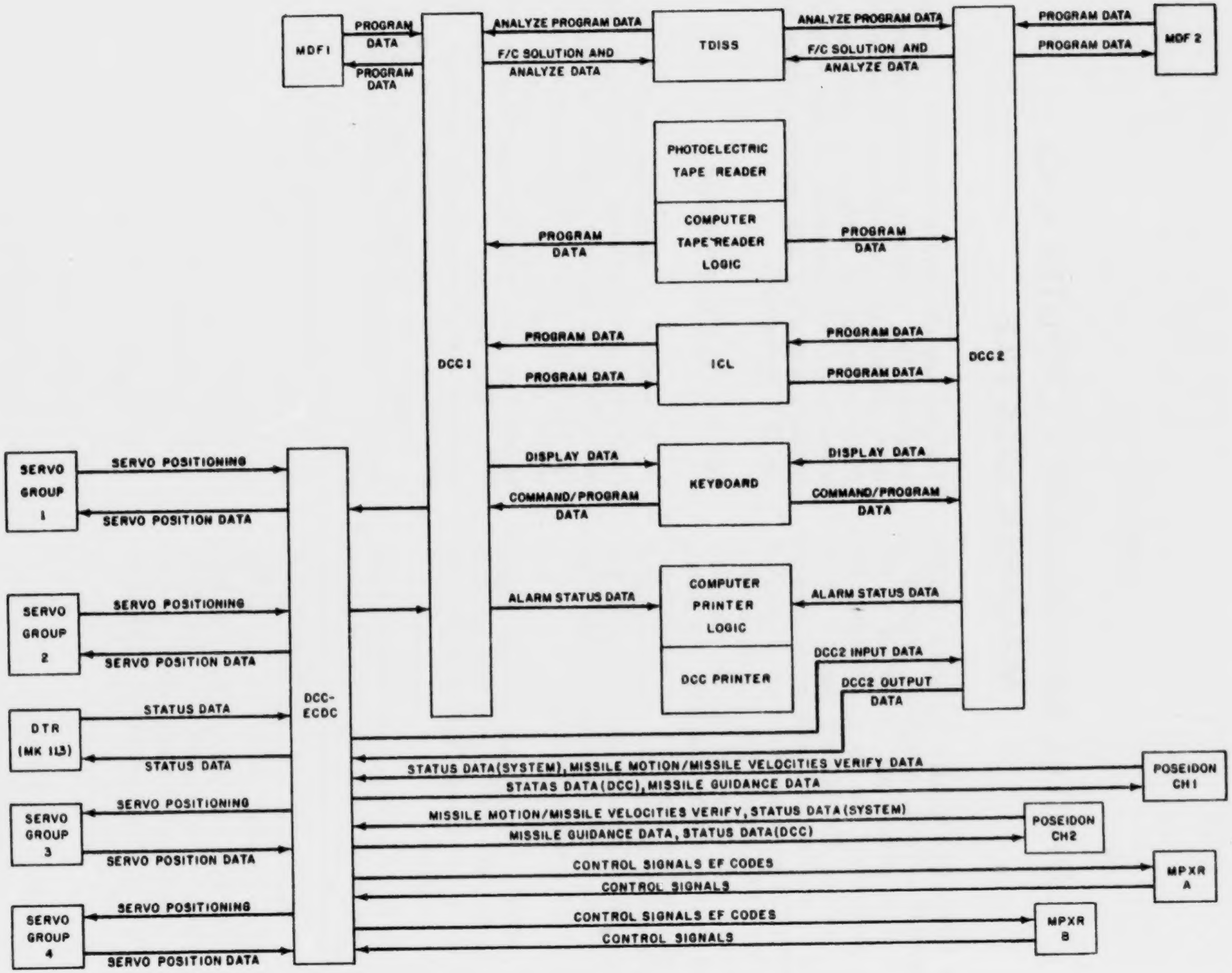
The DCC is functionally organized into five sections, as illustrated in figure 4-2. The sections function together under control of a computer program. The computer program consists of many instructions. Each instruction can enable a computer section to perform an operation. To understand the operation of the computer sections, you must first become familiar with the DCC instructions.

DCC INSTRUCTION WORDS

To perform its calculations, the DCC uses a repertoire of 44 different instructions. These instructions are listed in table 4-1, a foldout at the end of the chapter. The sequential order in which the instructions are executed varies among the many programs performed by the DCC. The sequence of execution and the particular instructions involved give each DCC program its own unique characteristics. To form a program, the instructions are stored in a particular numerical order in their addresses in memory.

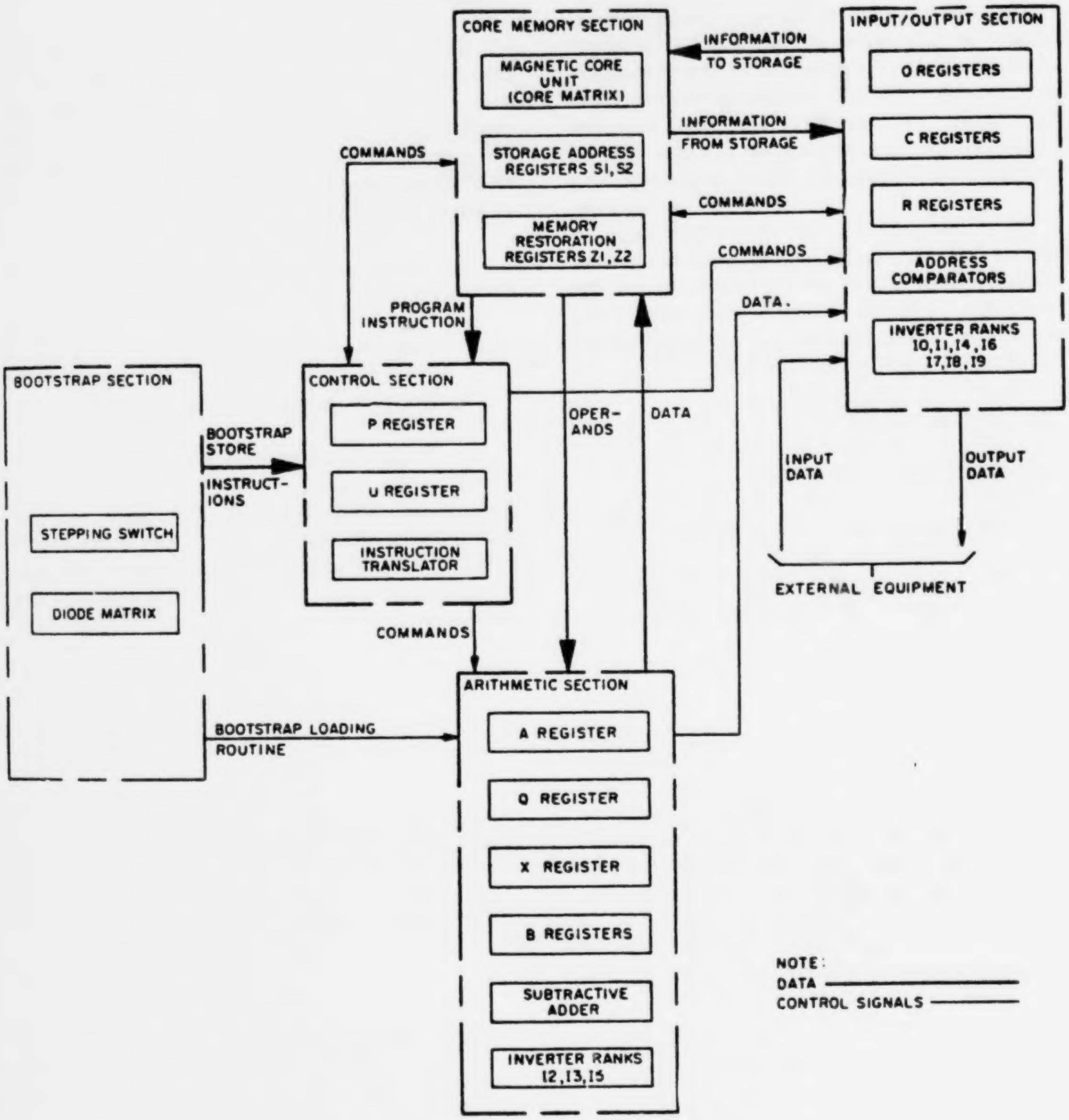
These instructions can be divided into seven basic types:

1. Shift
2. Arithmetic
3. Logical
4. Input/output
5. External function
6. Jump
7. Indexing


MDF1
PROGRAM DATA
PROGRAM DATA
DCC1
ANALYZE PROGRAM DATA
F/C SOLUTION AND ANALYZE DATA
TDISS
ANALYZE PROGRAM DATA
F/C SOLUTION AND ANALYZE DATA
DCC2
PROGRAM DATA
PROGRAM DATA
MDF 2
PHOTOELECTRIC TAPE READER
COMPUTER TAPE READER LOGIC
PROGRAM DATA
PROGRAM DATA
PROGRAM DATA
PROGRAM DATA
ICL
PROGRAM DATA
PROGRAM DATA
DISPLAY DATA
COMMAND/PROGRAM DATA
KEYBOARD
DISPLAY DATA
COMMAND/PROGRAM DATA
ALARM STATUS DATA
COMPUTER PRINTER LOGIC
DCC PRINTER
ALARM STATUS DATA
DCC2 INPUT DATA
DCC2 OUTPUT DATA
SERVO GROUP 1
SERVO POSITIONING
SERVO POSITION DATA
SERVO GROUP 2
SERVO POSITIONING
SERVO POSITION DATA
DTR (MK 113)
STATUS DATA
STATUS DATA
SERVO GROUP 3
SERVO POSITIONING
SERVO POSITION DATA
SERVO GROUP 4
SERVO POSITIONING
SERVO POSITION DATA
DCC-ECDC
STATUS DATA(SYSTEM), MISSILE MOTION/MISSILE VELOCITIES VERIFY DATA
STATAS DATA(DCC), MISSILE GUIDANCE DATA
POSEIDON CH1
MISSILE MOTION/MISSILE VELOCITIES VERIFY, STATUS DATA(SYSTEM)
MISSILE GUIDANCE DATA, STATUS DATA(DCC)
POSEIDON CH2
CONTROL SIGNALS EF CODES
CONTROL SIGNALS
MPXR A
CONTROL SIGNALS EF CODES
CONTROL SIGNALS
MPXR B

173.334

Figure 4-1.—DCC, Interface Simplified.


CORE MEMORY SECTION
MAGNETIC CORE UNIT (CORE MATRIX)
STORAGE ADDRESS REGISTERS S1, S2
MEMORY RESTORATION REGISTERS Z1, Z2
INFORMATION TO STORAGE
INFORMATION FROM STORAGE
COMMANDS
COMMANDS
COMMANDS
DATA.
INPUT/OUTPUT SECTION
O REGISTERS
C REGISTERS
R REGISTERS
ADDRESS COMPARATORS
INVERTER RANKS 10, 11, 14, 16 17, 18, 19
PROGRAM INSTRUCTION
BOOTSTRAP SECTION
STEPPING SWITCH
DIODE MATRIX
BOOTSTRAP STORE
INSTRUCT-IONS
CONTROL SECTION
P REGISTER
U REGISTER
INSTRUCTION TRANSLATOR
OPER-ANDS
DATA
INPUT DATA
OUTPUT DATA
EXTERNAL EQUIPMENT
COMMANDS
ARITHMETIC SECTION
A REGISTER
Q REGISTER
X REGISTER
B REGISTERS
SUBTRACTIVE ADDER
INVERTER RANKS 12, 13, 15
BOOTSTRAP LOADING ROUTINE
NOTE:
DATA
CONTROL SIGNALS

173.335

Figure 4-2.—DCC, Simplified Block Diagram.

Instruction Word Format

The instruction words are 24-bit words, arranged as illustrated in figure 4-3. The upper six bits (18-23) comprise the instruction code; there are 44 different configurations of these bits. Table 4-1 depicts the 44 different instruction codes as they appear in octal. Bits 15 through 17 are labeled the tag or designator bits.

These bits modify the instruction code to allow an instruction to be executed more than one way. Bits 00-14 are referred to as the execution address. Depending upon the instruction code, these bits can represent any of the following types of information:

1. Shift count (k)
2. An address in memory
3. An operand (y)
4. An I/O channel designator (x) and EF code (yyyy)

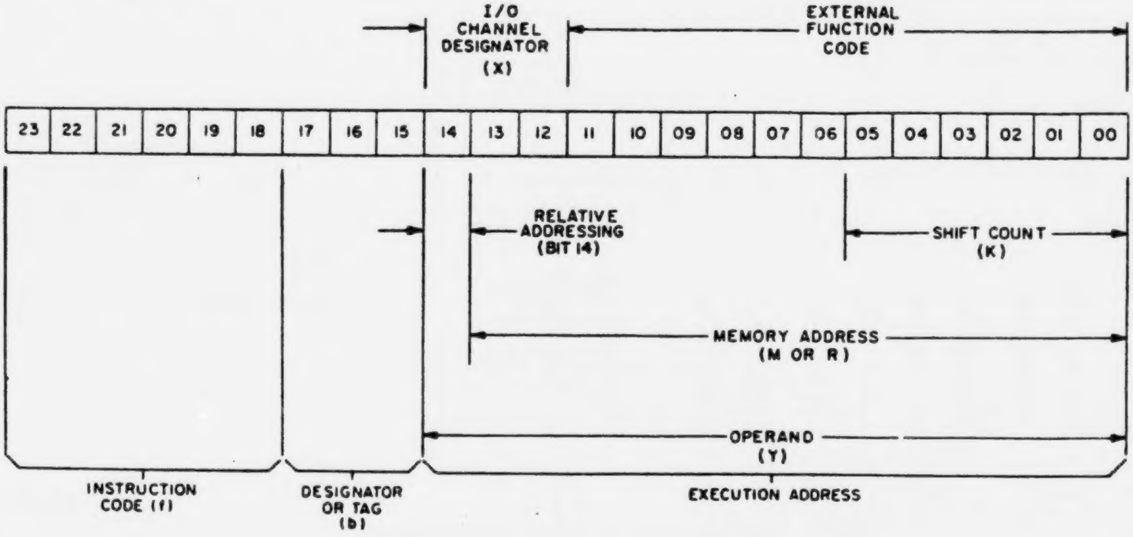
Execution Address Modification

Before an instruction is executed, it is first checked by the instruction word translator to see if the execution address requires modification. If the tag bits (15-17) are 0, the instruction is executed without modifying the execution address; this operation is referred to as direct addressing.

The following is a list of the types of addressing that require modifications:

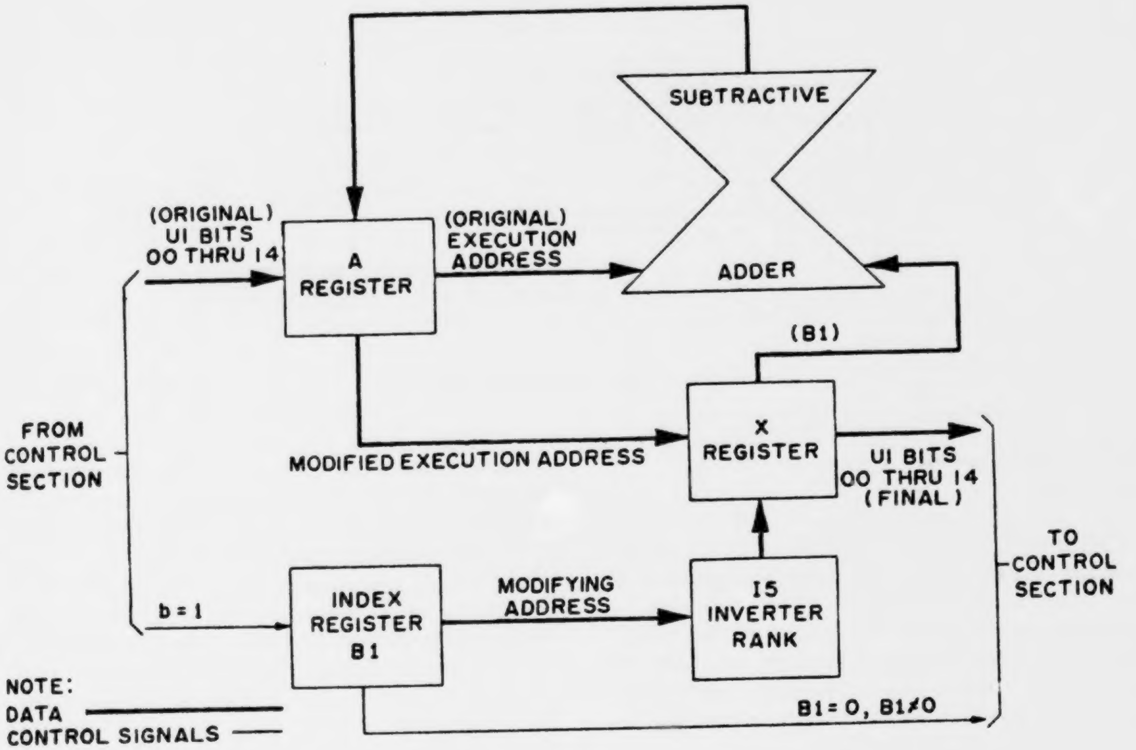
1. Indexing (IDX); Tag = 1 - 6
2. Indirect addressing (IA); Tag = 7
3. Relative addressing (RA); Bit 14 set

All of the types of execution address modification do not apply to every instruction. Table 4-1 indicates the application of the modification types to the applicable instructions.


I/O CHANNEL DESIGNATOR (X)
EXTERNAL FUNCTION CODE
23 22 21 20 19 18 17 16 15 14 13 12 11 10 09 08 07 06 05 04 03 02 01 00
RELATIVE ADDRESSING (BIT 14)
SHIFT COUNT (K)
MEMORY ADDRESS (M OR R)
OPERAND (Y)
INSTRUCTION CODE (f)
DESIGNATOR OR TAG (b)
EXECUTION ADDRESS

173.336

Figure 4-3.—Instruction Word Format.


SUBTRACTIVE
ADDER
(ORIGINAL) UI BITS 00 THRU 14
A REGISTER
(ORIGINAL) EXECUTION ADDRESS
(B1)
FROM CONTROL SECTION
X REGISTER
MODIFIED EXECUTION ADDRESS
UI BITS 00 THRU 14 (FINAL)
TO CONTROL SECTION
b = 1
INDEX REGISTER B1
MODIFYING ADDRESS
15 INVERTER RANK
NOTE:
DATA
CONTROL SIGNALS
B1 = 0, B1≠0

173.337

Figure 4-4.—Indexing Operation.

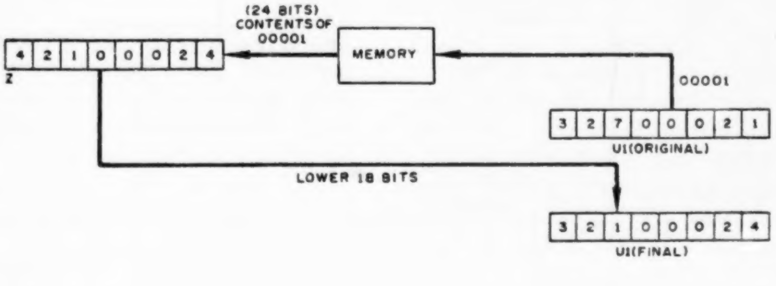
INDEXING.—This type of address modification is performed in the DCC arithmetic section, figure 4-4. The contents of one of the arithmetic section index registers are added to the lower 15 bits of the original instruction word.

INDIRECT ADDRESSING.—In this type of address modification, the contents of an address in memory, specified by the execution address of the original instruction, replace the lower 18 bits (tag and execution address) of the original instruction word (fig. 4-5).

RELATIVE ADDRESSING.—The relative addressing (RA) operation is performed in the arithmetic section, figure 4-6. The numerical value of the address that specifies the location of the original instruction word is added to the lower 15 bits of the same instruction word. Because bit 14 of the original instruction word was used only to designate that the relative addressing operation was required, it is cleared before the final modified execution address is placed back in the U1 register.

DCC MECHANIZATION

The following paragraphs will describe a logical sequence of operation, beginning with program loading operations, and ending with the DCC input/output operations with external equipment.



173.338

Figure 4-5.—Indirect Addressing Operation.

DCC Manual Control and Display

To initiate computer operation, some means must be provided for the operator to control and observe the operation. This function is provided on the front door face of the DCC, figure 4-7. This panel allows the operator to start, stop, step, load, modify instruction execution, test, and observe the contents of the various computer data registers.

Bootstrap Section

This section of the DCC satisfies the requirement for loading programs into the core memory in a matter of a few seconds. Once the operator starts the bootstrap operation, no further operator action is required for the DCC to execute the entire program under normal conditions.

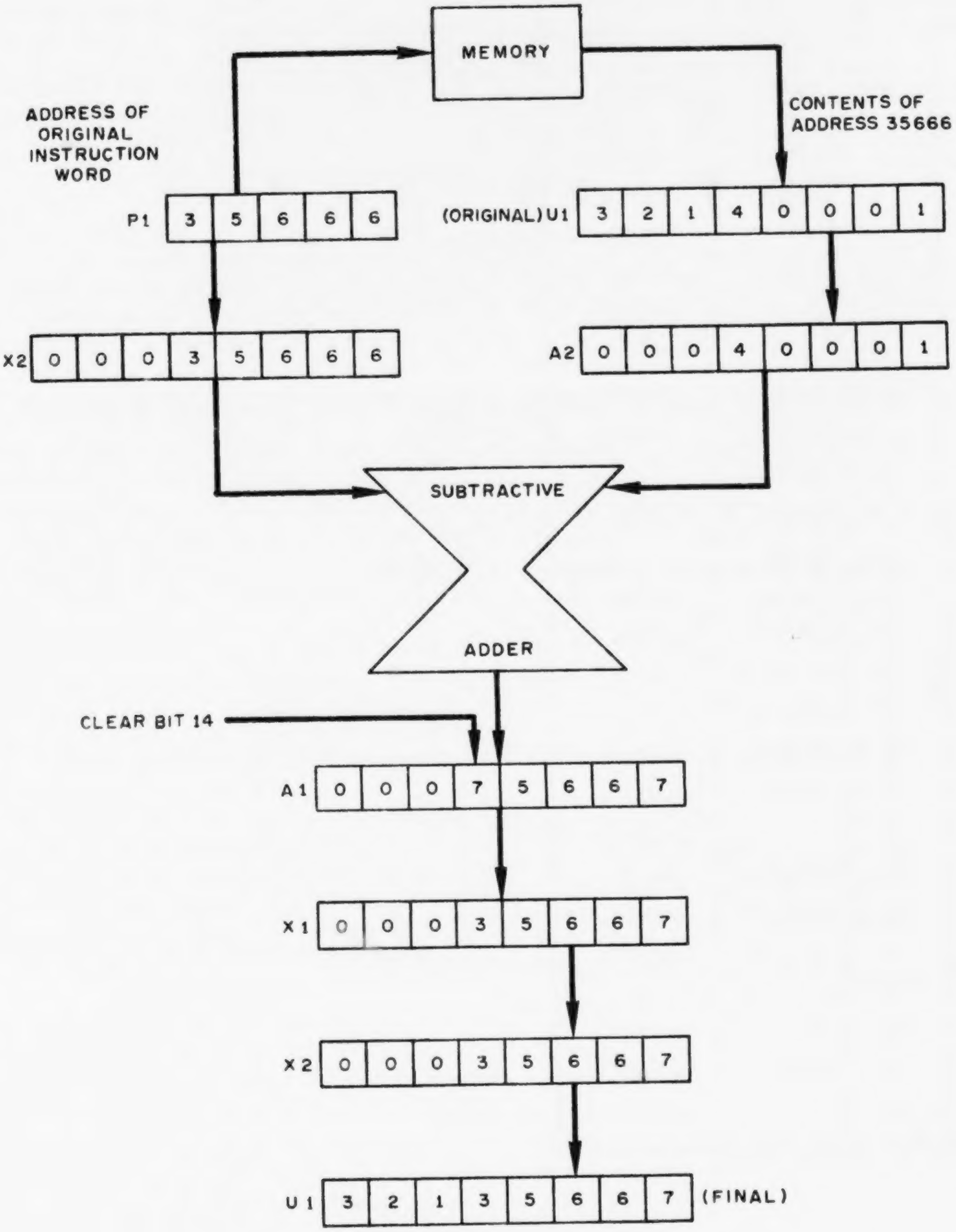
The main source of the DCC programs is the MDF. The DCC tape reader is also used as a source of computer programs. Figure 4-8 illustrates the bootstrap section interface between the MDF and the tape reader.

The bootstrap operation consists of two parts. The first part of the operation loads the bootstrap loading program into core memory. The second part consists of executing the bootstrap loading program, which loads the operational programs from the MDF or the tape reader. The second part of the operation is performed entirely without the bootstrap section.

The bootstrap operation must be initiated manually by the operator. Controls are locally provided on the front door of the DCC, figure 4-7. The operator prepares for the bootstrap operation by first depressing the STEP/STOP button to stop the computer if it is running; then, the MASTER CLEAR button is depressed to clear the DCC data registers. If the DCC is to be loaded from the MDF, the operator depresses the BOOTSTRAP switch to activate the bootstrap section. If the DCC is to be loaded from the tape reader, the operator would depress the SELECTIVE JUMP SET button before the BOOTSTRAP button is activated (fig. 4-7).

LOADING THE BOOTSTRAP PROGRAM.—When the BOOTSTRAP button is depressed, a stepping switch in the bootstrap section sequentially completes a circuit to ground for the rows of diodes in the diode matrix, figure 4-8. Table 4-2 illustrates the outputs of the diode matrix for each position of the stepping switch. After each instruction word is placed in the A and U registers, a STEP signal causes the instruction in the U register to be executed. This results in the contents of the A register being placed in memory at the address specified by the execution portion of the instruction in the U register. The instructions listed as contents U register, in table 4-2, comprise the bootstrap loading program.

EXECUTING THE BOOTSTRAP LOADING PROGRAM.—The last signal generated from the bootstrap section is a


MEMORY
ADDRESS OF ORIGINAL INSTRUCTION WORD
CONTENTS OF ADDRESS 35666
P1 3 5 6 6 6
(ORIGINAL) U1 3 2 1 4 0 0 0 1
X2 0 0 0 3 5 6 6 6
A2 0 0 0 4 0 0 0 1
SUBTRACTIVE
ADDER
CLEAR BIT 14
A1 0 0 0 7 5 6 6 7
X1 0 0 0 3 5 6 6 7
X2 0 0 0 3 5 6 6 7
U1 3 2 1 3 5 6 6 7 (FINAL)

173.339

Figure 4-6.—Relative Addressing Operation.

Table 4-2.—Diode Matrix Output

DIODE MATRIX OUTPUTS			
STEPPING SWITCH POSITION	DIODE COLUMN NUMBER	CONTENTS A REGISTER	CONTENTS U REGISTER
1	1	UNUSED	
2	2	STEP	
3	3	41237766	32037752
4	2	STEP	
5	4	50377775	32037753
6	2	STEP	
7	5	36077773	32037754
8	2	STEP	
9	6	32000013	32037755
10	2	STEP	
11	7	47031771	32037756
12	2	STEP	
13	8	30000013	32037757
14	2	STEP	
15	9	40137757	32037760
16	2	STEP	
17	10	50700003	32037761
18	2	STEP	
19	11	30237773	32037762
20	2	STEP	
21	12	03000006	32037763
22	2	STEP	
23	13	52237762	32037764
24	2	STEP	
25	14	40037752	32037765
26	2	STEP	
27	15	33737771	32037766
28	2	STEP	
29	16	41337754	32037770
30	2	STEP	
31	17	41337771	32037771
32	2	STEP	
33	18	47200000	32037772
34	2	STEP	
35	19	00000002	32037773
36	2	STEP	
37	20	47237776	32037774
38	2	STEP	
39	21	00000210	32037775
40	2	STEP	
41	22	47705371	32037776
42	2	STEP	
43	23	41337776	32037777
44	2	STEP	
45	24	41137753	32000001
46	2	STEP	
47	25	41337772	32000002
48	2	STEP	
49	26	53300000	32037767
50	27	CLR P START	

173.355

START signal (table 4-2). This signal initiates the execution of the bootstrap program. Upon receipt of the START signal, the control section reads the instruction at address 00001 (41 1 37753) from memory. This instruction will determine in what manner the remainder of the program will be executed (see 41 1 code, table 4-1). Reference to tables 4-1 and 4-2 will enable you to translate the bootstrap loading program.

Control Section

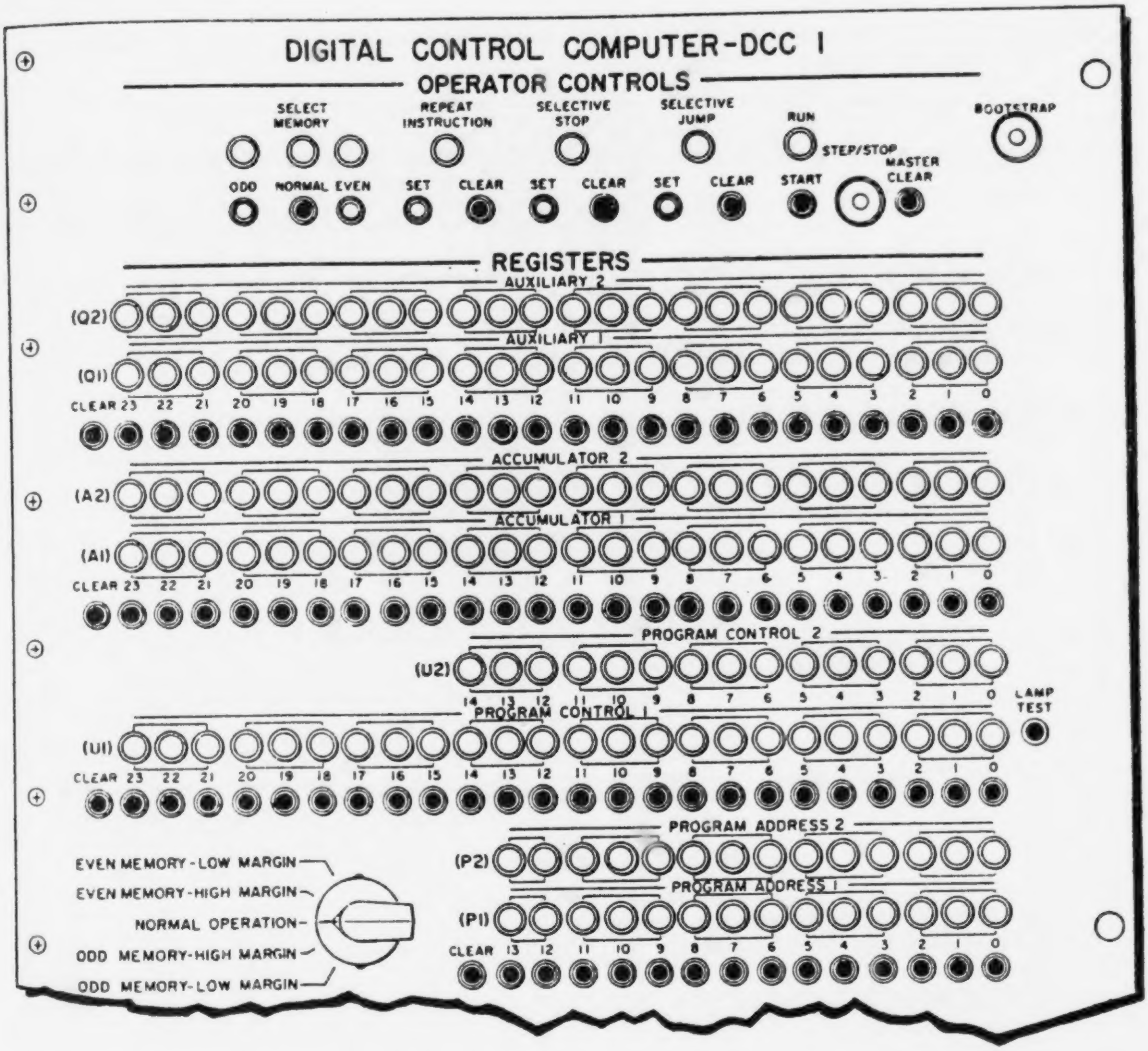
Program control of the DCC circuits is mechanized through the control section. In basic terms the control section functions as follows: The control section reads an instruction word from memory and translates it. The translation results in the enabling of circuits that control the sequence of steps and the circuits that perform the steps of executing the instruction.

The control section also contains circuits that provide continuity between the completion of one instruction execution operation and the initiation of the next instruction. Figure 4-9 illustrates the control section elements that perform the operations mentioned above.

PROGRAM CONTROL REGISTERS (U).—The U registers are comprised of a U1 and a U2 register. The U1 register receives the instruction word from memory and distributes the upper 9 bits (Op code and tag) to the instruction translator and the lower 15 bits (execution address) to the U2 register. The U1 register serves as a temporary storage register for the instruction until its execution is complete. The U2 register can feed its contents to either memory or the arithmetic section, depending upon the requirements of the basic instruction.

INSTRUCTION TRANSLATOR.—The instruction translator translates the Op code and tag into signals that select and enable the circuits required to execute the particular instruction.

PROGRAM ADDRESS REGISTER (P).—The P register is comprised of the P1 and P2 registers. The two registers together function as a counter. This ability allows an advance P1 pulse to increment the registers by 1, and thus

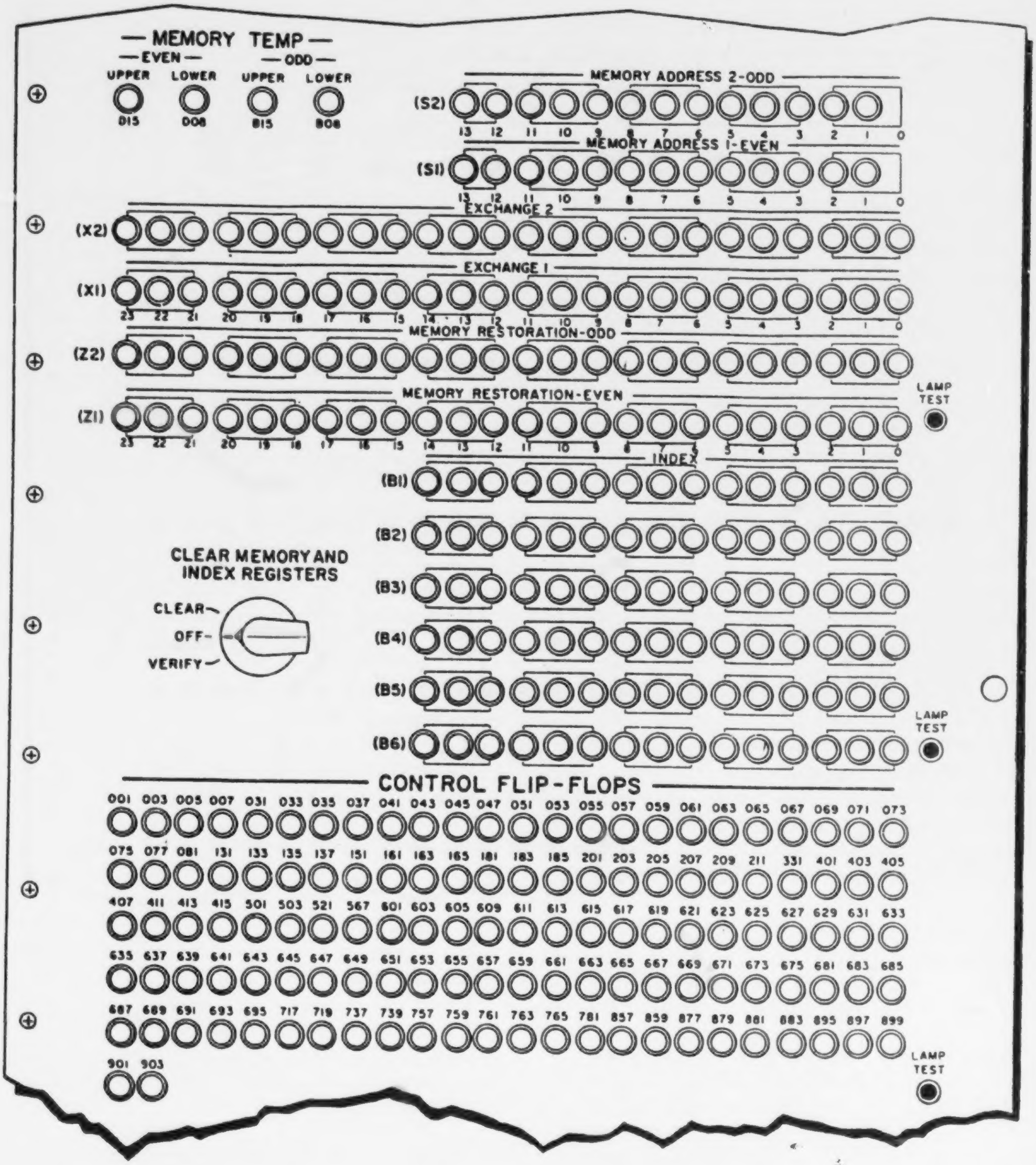

DIGITAL CONTROL COMPUTER-DCC I
OPERATOR CONTROLS
SELECT MEMORY
REPEAT INSTRUCTION
SELECTIVE STOP
SELECTIVE JUMP
RUN
BOOTSTRAP
STEP/STOP
MASTER CLEAR
ODD
NORMAL
EVEN
SET
CLEAR
SET
CLEAR
SET
CLEAR
START
REGISTERS
AUXILIARY 2
(Q2)
AUXILIARY 1
(Q1)
CLEAR 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
ACCUMULATOR 2
(A2)
ACCUMULATOR 1
(A1)
CLEAR 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
PROGRAM CONTROL 2
(U2)
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
LAMP TEST
PROGRAM CONTROL 1
(U1)
CLEAR 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
PROGRAM ADDRESS 2
(P2)
PROGRAM ADDRESS 1
(P1)
CLEAR 13 12 11 10 9 8 7 6 5 4 3 2 1 0
EVEN MEMORY-LOW MARGIN
EVEN MEMORY-HIGH MARGIN
NORMAL OPERATION
ODD MEMORY-HIGH MARGIN
ODD MEMORY-LOW MARGIN

173.340

Figure 4-7.—DCC Control and Display Panel.

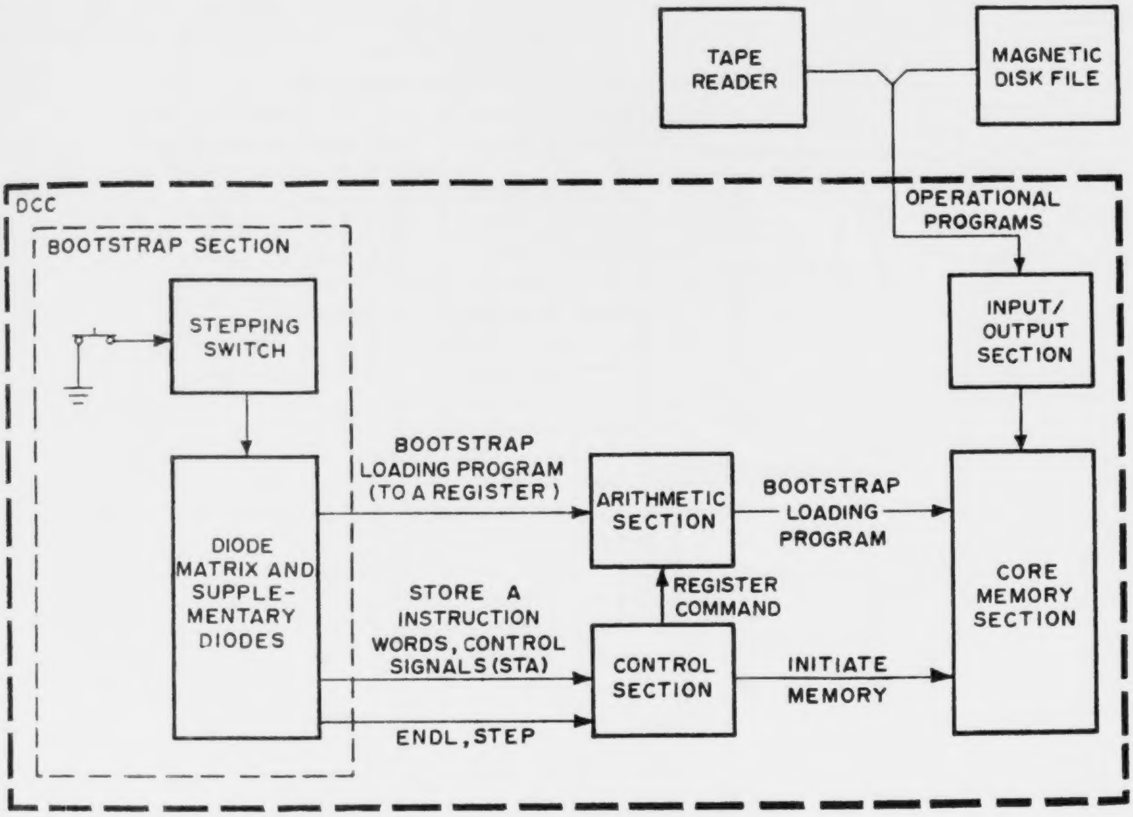
allows the next instruction to be read from the next sequential address in memory (fig. 4-9). The primary purpose and function of the P registers is to hold the address of the instruction in progress and then feed the address of the next instruction to memory. If a jump instruction shows up in the U register, the lower 14 bits can be transferred to the P register to cause the address of the next instruction to be obtained from a memory location that does not follow in sequential order.

EXECUTION SEQUENCES.—The execution of an instruction is not a one-step operation. Each step of execution is basically a transfer of data between registers: the data may be


— MEMORY TEMP —
— EVEN —
— ODD —
UPPER
LOWER
UPPER
LOWER
D15
D08
B15
B08
MEMORY ADDRESS 2-ODD
(S2)
13 12 11 10 9 8 7 6 5 4 3 2 1 0
MEMORY ADDRESS 1-EVEN
(S1)
13 12 11 10 9 8 7 6 5 4 3 2 1 0
EXCHANGE 2
(X2)
EXCHANGE 1
(X1)
23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
MEMORY RESTORATION-ODD
(Z2)
MEMORY RESTORATION-EVEN
(Z1)
23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
LAMP TEST
INDEX
(B1)
(B2)
(B3)
(B4)
(B5)
(B6)
CLEAR MEMORY AND INDEX REGISTERS
CLEAR
OFF
VERIFY
LAMP TEST
CONTROL FLIP-FLOPS
001 003 005 007 031 033 035 037 041 043 045 047 051 053 055 057 059 061 063 065 067 069 071 073
075 077 081 131 133 135 137 151 161 163 165 181 183 185 201 203 205 207 209 211 331 401 403 405
407 411 413 415 501 503 521 567 601 603 605 609 611 613 615 617 619 621 623 625 627 629 631 633
635 637 639 641 643 645 647 649 651 653 655 657 659 661 663 665 667 669 671 673 675 681 683 685
687 689 691 693 695 717 719 737 739 757 759 761 763 765 781 857 859 877 879 881 883 895 897 899
901 903
LAMP TEST

173.340

Figure 4-7.—DCC Control and Display Panel—Continued.


TAPE READER
MAGNETIC DISK FILE
DCC
OPERATIONAL PROGRAMS
BOOTSTRAP SECTION
STEPPING SWITCH
INPUT/ OUTPUT SECTION
BOOTSTRAP LOADING PROGRAM (TO A REGISTER)
ARITHMETIC SECTION
BOOTSTRAP LOADING PROGRAM
DIODE MATRIX AND SUPPLE-MENTARY DIODES
REGISTER COMMAND
CORE MEMORY SECTION
STORE A INSTRUCTION WORDS, CONTROL SIGNALS (STA)
CONTROL SECTION
INITIATE MEMORY
ENDL, STEP

173.341

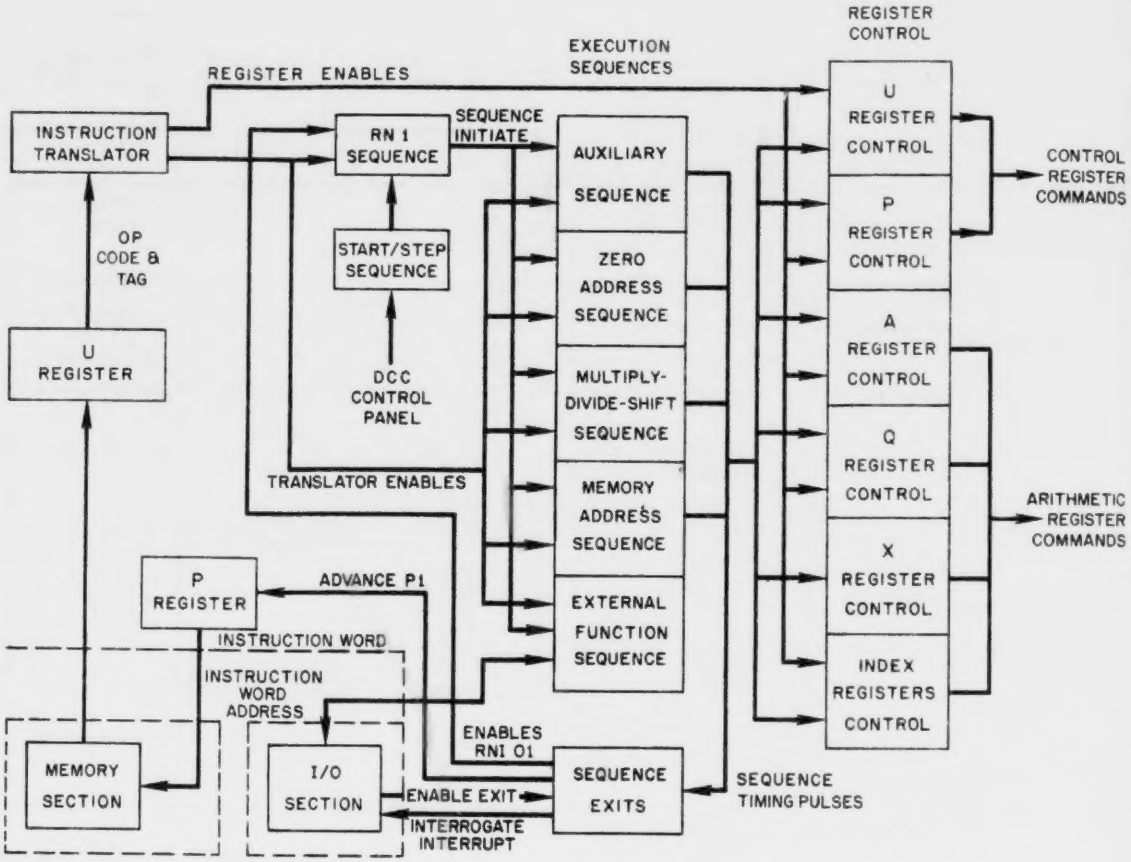
Figure 4-8.—Bootstrap Section Block Diagram.

modified by the transfer or simply duplicated. The sequence in which these data transfers take place is controlled by the execution sequence logic circuits as illustrated in figure 4-9.

Each of the execution sequences consists of a chain of control delays; each control delay within a sequence issues a pulse that is referred to as a sequence timing pulse. The execution sequence is initiated by the RNI sequence in coincidence with an enabling signal from the instruction translator logic. Figure 4-10 illustrates a typical execution sequence circuit operating on an instruction. The outputs of each control delay are fed to the applicable register control circuits, in sequence, to cause the instruction to be executed.

The auxiliary (AUX) sequence, figure 4-9, controls the sequence of execution of all index instructions and the address modification operations. Other instructions controlled by the AUX sequence are listed in table 4-1. When address modification is indicated for an instruction, the AUX sequence controls the modification. The execution sequencing of the same instruction is then performed by one of the other execution sequences.

For certain instructions requiring no memory reference, the Zero Address (ZA) sequence is used to control the execution. The ZA sequence can control the execution of some of the instruction operations while another sequence is controlling memory reference operation.


REGISTER CONTROL
EXECUTION SEQUENCES
REGISTER ENABLES
INSTRUCTION TRANSLATOR
RN 1 SEQUENCE
SEQUENCE INITIATE
AUXILIARY SEQUENCE
U REGISTER CONTROL
CONTROL REGISTER COMMANDS
P REGISTER CONTROL
OP CODE & TAG
START/STEP SEQUENCE
ZERO ADDRESS SEQUENCE
A REGISTER CONTROL
U REGISTER
DCC CONTROL PANEL
MULTIPLY-DIVIDE-SHIFT SEQUENCE
Q REGISTER CONTROL
TRANSLATOR ENABLES
MEMORY ADDRESS SEQUENCE
ARITHMETIC REGISTER COMMANDS
X REGISTER CONTROL
P REGISTER
ADVANCE P1
EXTERNAL FUNCTION SEQUENCE
INSTRUCTION WORD
INSTRUCTION WORD ADDRESS
INDEX REGISTERS CONTROL
ENABLES RNI 01
MEMORY SECTION
I/O SECTION
SEQUENCE EXITS
ENABLE EXIT
INTERROGATE INTERRUPT
SEQUENCE TIMING PULSES

173.342

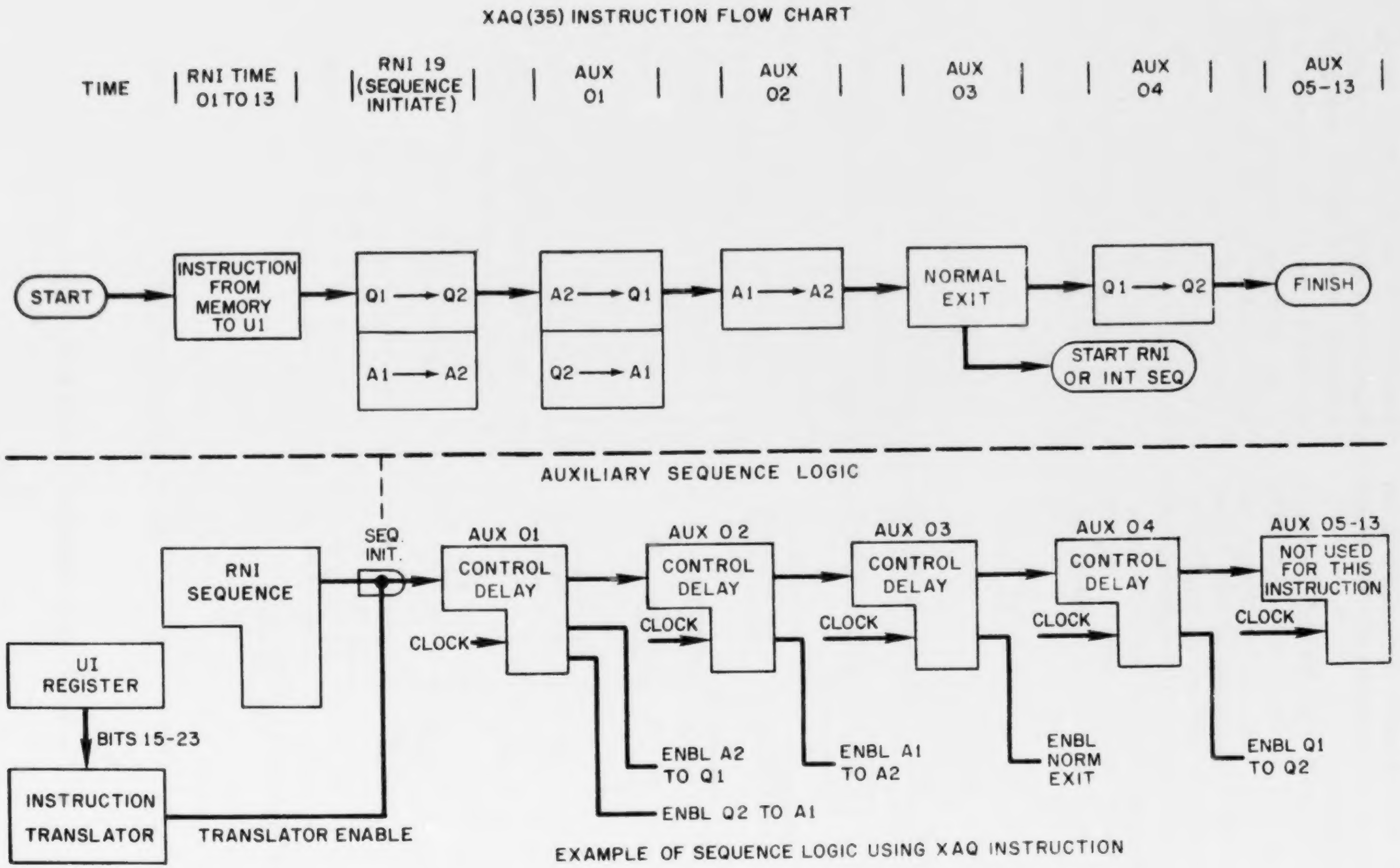
Figure 4-9.—Control Section Block Diagram.

The Memory Address (MA) sequence controls the execution of instructions that require a memory reference. The MA sequence can control the entire execution, or it can be initiated by another sequence, such as the MDS sequence, to perform only the memory reference requirements of an instruction. The MA sequence controls the execution of those instructions as indicated in table 4-1.

The Multiply-Divide-Shift (MDS) sequence controls the execution of the shift instructions and, in conjunction with the MA sequence, also controls the execution of the multiply and divide instructions.

The External Function (EF) sequence controls the execution of the Op Code 47 instructions (see table 4-1). The 47 instructions pertain to input/output operations with external equipment. The major portion of input/output operations is controlled by the input/output section; the EF sequence logic controls only those operations performed by circuits not in the input/output section.

The Read-Next-Instruction (RNI) sequence controls the operations that read the next instruction from memory, controls indirect addressing operations, and initiates the execution sequences.


XAQ(35) INSTRUCTION FLOW CHART

TIME
RNI TIME 01 TO 13
RNI 19 (SEQUENCE INITIATE)
AUX 01
AUX 02
AUX 03
AUX 04
AUX 05-13
START
INSTRUCTION FROM MEMORY TO UI
Q1 → Q2
A1 → A2
A2 → Q1
Q2 → A1
A1 → A2
NORMAL EXIT
START RNI OR INT SEQ
Q1 → Q2
FINISH
AUXILIARY SEQUENCE LOGIC
UI REGISTER
BITS 15-23
INSTRUCTION TRANSLATOR
TRANSLATOR ENABLE
RNI SEQUENCE
SEQ. INIT.
AUX 01
CONTROL DELAY
CLOCK
ENBL A2 TO Q1
ENBL Q2 TO A1
AUX 02
CONTROL DELAY
CLOCK
ENBL A1 TO A2
AUX 03
CONTROL DELAY
CLOCK
ENBL NORM EXIT
AUX 04
CONTROL DELAY
CLOCK
ENBL Q1 TO Q2
AUX 05-13
NOT USED FOR THIS INSTRUCTION
CLOCK

EXAMPLE OF SEQUENCE LOGIC USING XAQ INSTRUCTION

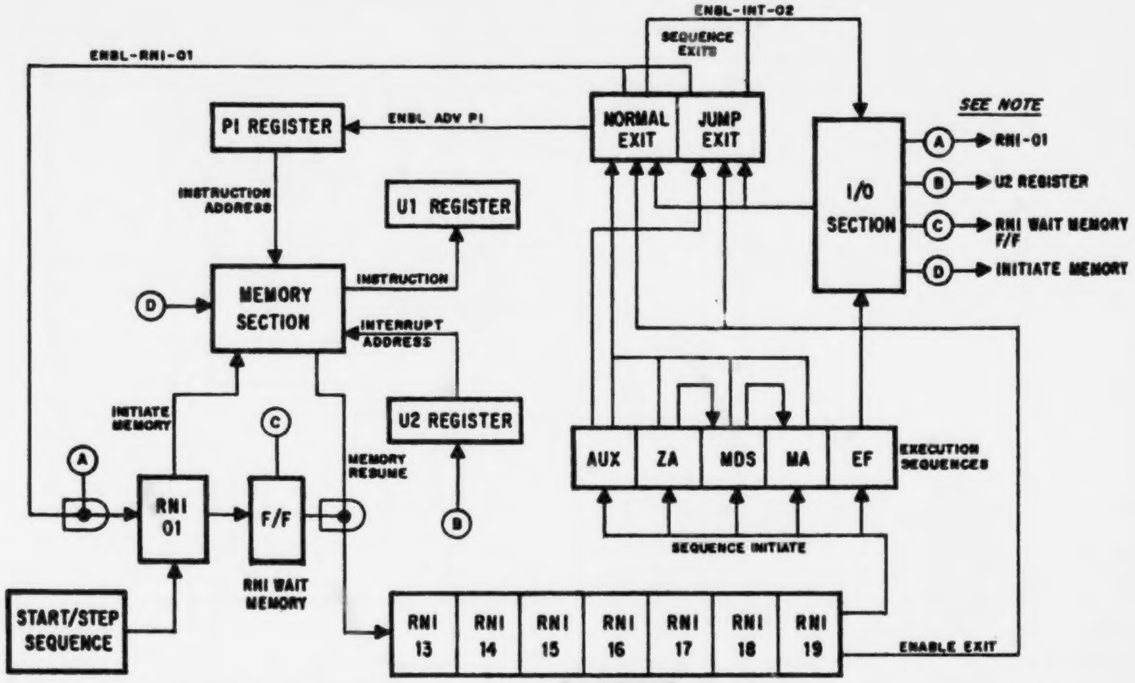
173.343

Figure 4-10.—Typical Execution Sequence Circuit.

The sequence exit logic provides the continuity between the completion of one instruction and the beginning of the next, and also performs logic decisions concerning which instruction address is to be selected as the source of the next instruction.

The RNI sequence and the sequence exit logic are illustrated in figure 4-11. The RNI sequence consists of eight control delays; the sequence exit logic is comprised of two control delays. The RNI sequence can be initiated by the start/step sequence or the sequence exit logic. Once initiated, the RNI sequence causes a memory reference to be made. The RNI sequence then waits for a memory resume signal and upon receipt of this signal continues the RNI operation. The RNI sequence then initiates one of the execution sequences to control the execution of the instruction. At the end of the instruction execution, the sequence exit logic is activated. The sequence exit logic interrogates the I/O section for the presence of an interrupt. If an interrupt requires processing, the I/O section takes control of reading the next instruction. If there is no interrupt to be processed, the sequence exit logic causes the RNI sequence to repeat its normal operation.

The address that is referenced for the next instruction is determined by the contents of the P register, which, in turn, is determined by


ENBL-INT-02
SEQUENCE EXITS
ENBL-RNI-01
PI REGISTER
ENBL ADV PI
NORMAL EXIT
JUMP EXIT
SEE NOTE
I/O SECTION
A
RNI-01
B
U2 REGISTER
C
RNI WAIT MEMORY F/F
D
INITIATE MEMORY
INSTRUCTION ADDRESS
U1 REGISTER
INSTRUCTION
D
MEMORY SECTION
INTERRUPT ADDRESS
INITIATE MEMORY
C
U2 REGISTER
AUX
ZA
MDS
MA
EF
EXECUTION SEQUENCES
A
MEMORY RESUME
RNI 01
F/F
B
SEQUENCE INITIATE
RNI WAIT MEMORY
START/STEP SEQUENCE
RNI 13
RNI 14
RNI 15
RNI 16
RNI 17
RNI 18
RNI 19
ENABLE EXIT
RNI SEQUENCE

NOTE: IF THE I/O SECTION HAS AN INTERRUPT TO BE PROCESSED, THE ENBL-INT-01 SIGNAL WILL ENABLE.

LEGEND:

Ⓐ EXIT TO RNI DISABLED.

Ⓑ INTERRUPT INSTRUCTION ADDRESS PLACED IN U2 REGISTER.

Ⓒ SET RNI WAIT MEMORY.

Ⓓ INITIATE MEMORY, UPON GENERATION OF MEMORY RESUME, RNI SEQUENCE WILL PROCEED IN NORMAL MANNER.

173.344

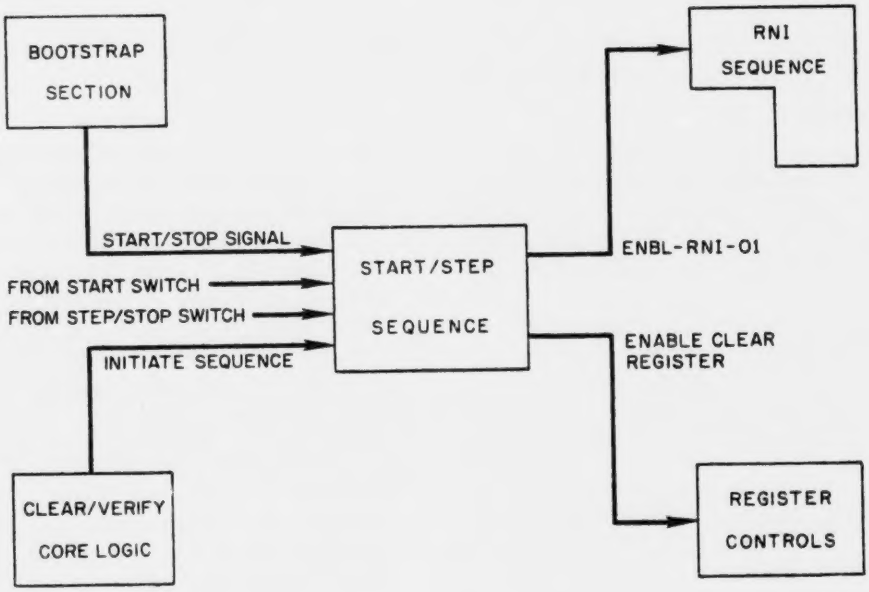
Figure 4-11.—RNI Sequence and Sequence Exit Block Diagram.

which exit control delay was activated by the previous instructions. The normal exit will cause the P register to be incremented by 1 and the next sequential address to be accessed. The jump exit causes the execution address portion of the previous instruction to be loaded into the P register.

START/STEP SEQUENCE.–The purpose of the start/step sequence logic is to control the operations that initiate program execution after the DCC has been stopped. Figure 4-12 illustrates the interface of the sequence with other DCC circuits. The inputs to the start/step logic come from the operator controls on the DCC front door face (fig. 4-7), and from the bootstrap section.

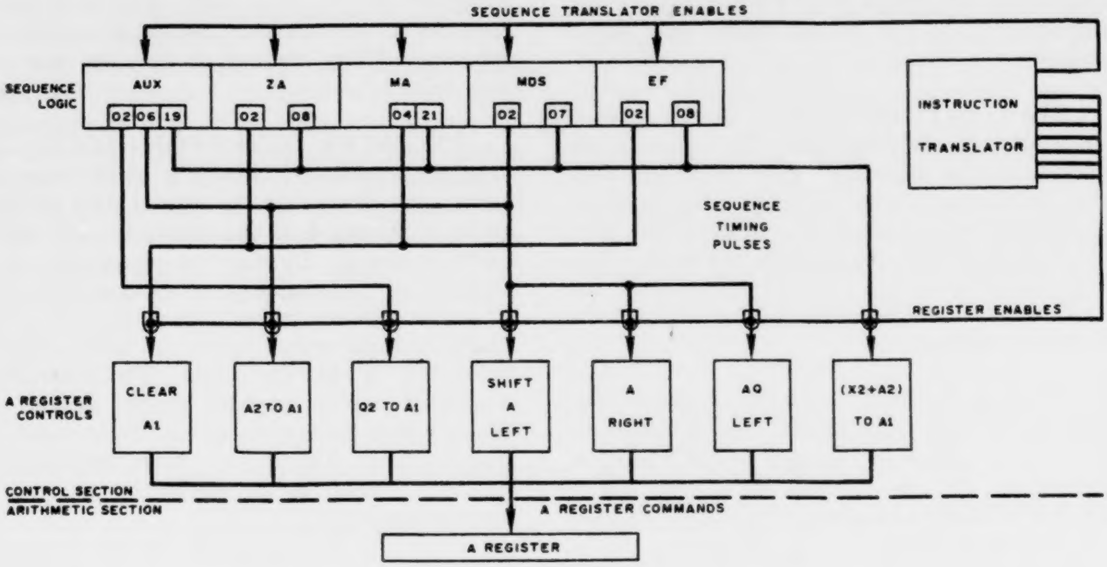
CLEAR/VERIFY CORE LOGIC.–The clear/verify core logic allows the operator to clear core memory and the index registers. Operation of the CLEAR MEMORY AND INDEX REGISTERS switch, figure 4-7, to the CLEAR position causes all logic 0's to be written into core memory and the index registers. Positioning the switch to the VERIFY position causes the contents of all memory addresses to be sequentially placed in the Z registers so the operator can visually verify the memory address contents as they are displayed (fig. 4-7).

REGISTER CONTROL LOGIC.–The register control circuits (fig. 4-9) issue the commands that cause the register data transfers to occur. Figure 4-13 illustrates a typical register control circuit. During the execution of an instruction, the register control circuits receive sequence timing pulses, from the execution sequence logic, which determine when a register command is to be issued. The instruction translator delivers register enable signals that select which commands are to be generated. As illustrated in figure 4-9, there are separate control circuits for the arithmetic and control section registers.


BOOTSTRAP SECTION
RNI SEQUENCE
START/STOP SIGNAL
FROM START SWITCH
FROM STEP/STOP SWITCH
INITIATE SEQUENCE
START/STEP SEQUENCE
ENBL-RNI-01
ENABLE CLEAR REGISTER
CLEAR/VERIFY CORE LOGIC
REGISTER CONTROLS

173.345

Figure 4-12.–Start/Step Sequence Interface.


SEQUENCE TRANSLATOR ENABLES
SEQUENCE LOGIC
AUX
02
06
19
ZA
02
08
MA
04
21
MDS
02
07
EF
02
08
INSTRUCTION TRANSLATOR
SEQUENCE TIMING PULSES
REGISTER ENABLES
A REGISTER CONTROLS
CLEAR A1
A2 TO A1
Q2 TO A1
SHIFT A LEFT
A RIGHT
AQ LEFT
(X2+A2) TO A1
CONTROL SECTION
ARITHMETIC SECTION
A REGISTER COMMANDS
A REGISTER

173.346

Figure 4-13.—Typical Register Control Circuit.

Memory Section

The DCC core memory section (fig. 4-14) provides the storage for the instruction words that comprise the DCC programs. The memory section can be divided into four major circuit groups:

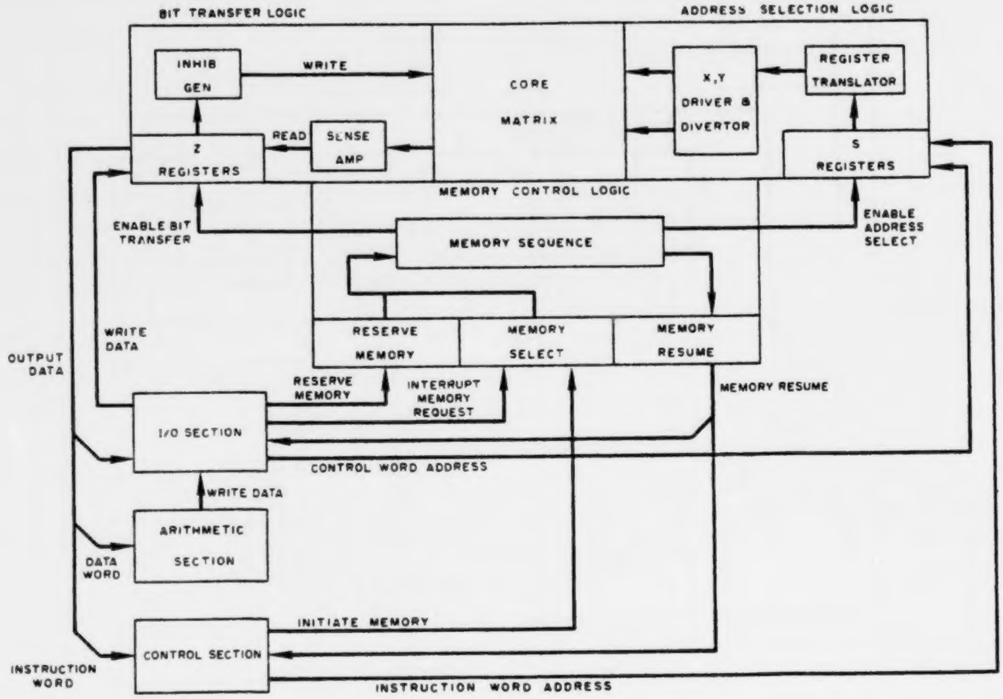
1. CORE MATRIX
2. MEMORY CONTROL LOGIC
3. BIT TRANSFER LOGIC
4. ADDRESS SELECTION LOGIC

CORE MATRIX.—The core matrix is a random access, magnetic core device that has a total storage capacity of 16,384 24-bit words. The memory is divided into two sections (odd and even), which are also divided into two stacks (upper and lower). Odd and even numbered addresses are assigned to the sections as applicable; one stack contains the lower 12 bits of all of the assigned addresses, and the other stack contains the upper 12 bits of all of the assigned addresses for that section.

MEMORY CONTROL LOGIC.—The memory control logic responds to requests by the control and I/O sections of the DCC. In response to these requests, the memory control logic sequentially enables the address selection logic and the bit transfer logic to select and read out or write into an address in core memory. Upon completion of the read or write operation, the memory control logic notifies the requesting DCC section that the memory cycle is complete (fig. 4-14).

ADDRESS SELECTION CIRCUITS.—In response to control signals from memory control, the address selection circuits transfer addresses from the control and I/O sections to the S registers; the address selection circuits then translate the address bits into core memory enabling signals to activate the selected address cores.

BIT TRANSFER LOGIC.—This circuitry receives the contents of a selected memory address and provides the path to store data back


BIT TRANSFER LOGIC
ADDRESS SELECTION LOGIC
INHIB GEN
WRITE
CORE MATRIX
X,Y DRIVER & DIVERTOR
REGISTER TRANSLATOR
READ
SENSE AMP
Z REGISTERS
S REGISTERS
MEMORY CONTROL LOGIC
ENABLE BIT TRANSFER
MEMORY SEQUENCE
ENABLE ADDRESS SELECT
RESERVE MEMORY
MEMORY SELECT
MEMORY RESUME
OUTPUT DATA
WRITE DATA
RESERVE MEMORY
INTERRUPT MEMORY REQUEST
MEMORY RESUME
I/O SECTION
CONTROL WORD ADDRESS
WRITE DATA
ARITHMETIC SECTION
DATA WORD
INITIATE MEMORY
CONTROL SECTION
INSTRUCTION WORD
INSTRUCTION WORD ADDRESS

173.347

Figure 4-14.—Memory Section Block Diagram.

into memory. The bit transfer logic is enabled by control signals from the memory control logic. The transfer of data out of the Z register is enabled by control signals from the DCC section receiving the data.

Arithmetic Section

The arithmetic section performs the calculations for the DCC. The operations performed by the arithmetic section can be divided into six types:

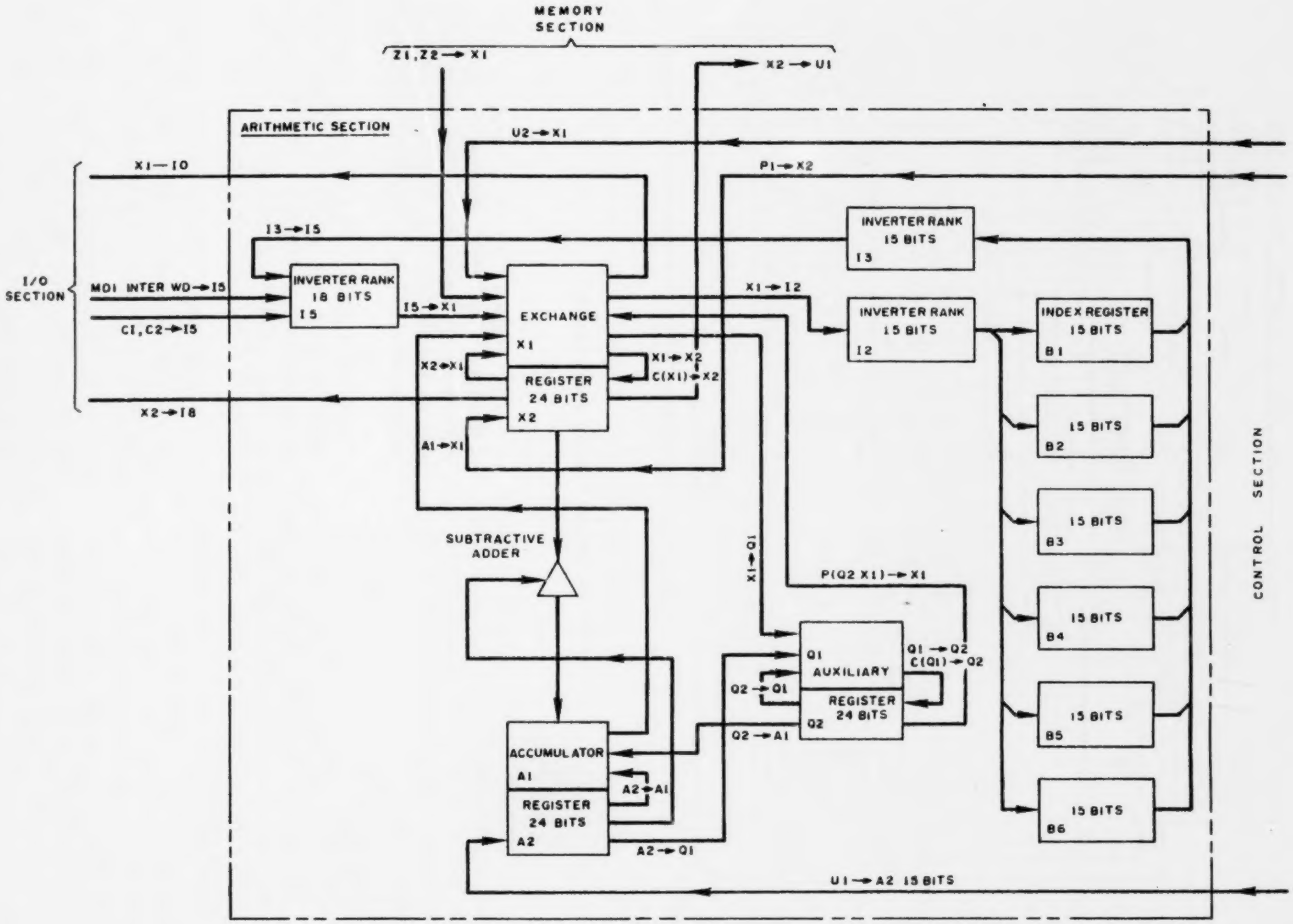
1. Transfer
2. Shifting
3. Indexing
4. Logical
5. Mathematical
6. Quantity sensing

The register transfers involved with the operation of the arithmetic section are illustrated in figure 4-15. The commands that enable the register transfers originate from the register control logic in the DCC control section.

X REGISTER.—The X register provides a path between the arithmetic section and the other sections of the DCC. The X register also provides temporary storage for one of the operands during arithmetic operations.

A REGISTER.—The A register contains one of the operands and provides temporary storage for the final results of arithmetic operations.

Q REGISTER.—The Q register can be used as an extension of the A register or to provide temporary storage for subtotals during arithmetic operations.


MEMORY SECTION
Z1,Z2 → X1
X2 → U1
ARITHMETIC SECTION
U2 → X1
X1 — I0
P1 → X2
I3 → I5
INVERTER RANK 15 BITS I3
I/O SECTION
MDI INTER WD → I5
C1,C2 → I5
INVERTER RANK 18 BITS I5
I5 → X1
EXCHANGE X1
REGISTER 24 BITS X2
X1 → I2
INVERTER RANK 15 BITS I2
INDEX REGISTER 15 BITS B1
15 BITS B2
15 BITS B3
15 BITS B4
15 BITS B5
15 BITS B6
X2 → X1
X1 → X2
C(X1) → X2
X2 → I8
A1 → X1
SUBTRACTIVE ADDER
X1 → Q1
P(Q2 X1) → X1
Q1 AUXILIARY
REGISTER 24 BITS Q2
Q1 → Q2
C(Q1) → Q2
Q2 → Q1
Q2 → A1
ACCUMULATOR A1
REGISTER 24 BITS A2
A2 → A1
A2 → Q1
U1 → A2 15 BITS
CONTROL SECTION

173.348

Figure 4-15.—Arithmetic Section Data Transfer.

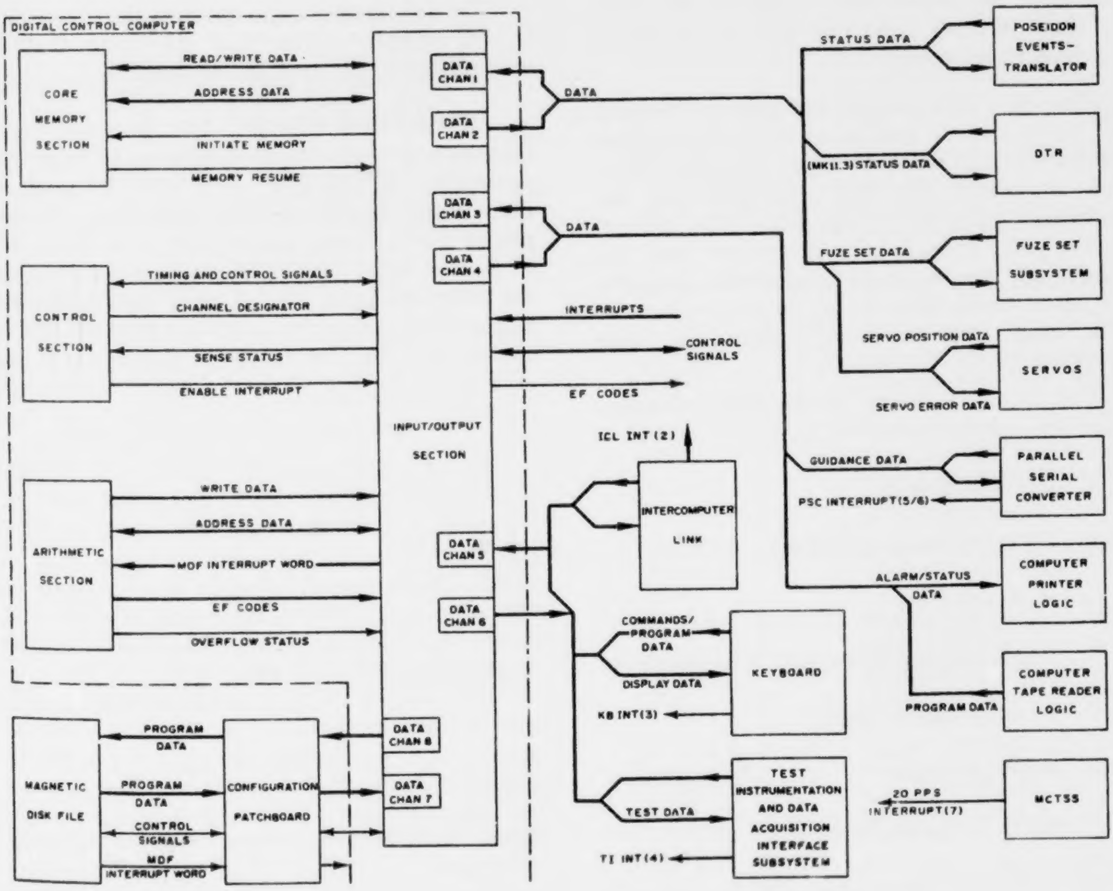
SUBTRACTIVE ADDER.–The subtractive adder ANDs the operands in X2 and A2. The outputs of the subtractive adder are toggle signals that set respective bits in the A register to produce the sum of the two operands.

INDEX REGISTERS.–The B registers are storage registers for operands that are used to modify addresses, shift counts, and other operands. Inverter ranks I2 and I3 provide the paths for the inputs and outputs respectively.

INVERTER RANK I5.–This rank of inverters allows the X register to receive inputs from various sources, but on a selective basis. Selection is made by control gating signals sent to the inverter rank by the control section.

Input/Output Section

The I/O section provides the communication link between the DCC and peripheral equipment. Figure 4-16 illustrates the DCC I/O section and peripheral equipment interface. The I/O section is analogous to a central telephone switchboard complex. To complete the analogy, the DCC could be likened to a large office


DIGITAL CONTROL COMPUTER
CORE MEMORY SECTION
READ/WRITE DATA
ADDRESS DATA
INITIATE MEMORY
MEMORY RESUME
CONTROL SECTION
TIMING AND CONTROL SIGNALS
CHANNEL DESIGNATOR
SENSE STATUS
ENABLE INTERRUPT
ARITHMETIC SECTION
WRITE DATA
ADDRESS DATA
MOF INTERRUPT WORD
EF CODES
OVERFLOW STATUS
INPUT/OUTPUT SECTION
DATA CHAN 1
DATA CHAN 2
DATA CHAN 3
DATA CHAN 4
DATA CHAN 5
DATA CHAN 6
DATA CHAN 8
DATA CHAN 7
MAGNETIC DISK FILE
PROGRAM DATA
PROGRAM DATA
CONTROL SIGNALS
MOF INTERRUPT WORD
CONFIGURATION PATCHBOARD
DATA
DATA
INTERRUPTS
CONTROL SIGNALS
EF CODES
ICL INT (2)
INTERCOMPUTER LINK
COMMANDS/ PROGRAM DATA
DISPLAY DATA
KEYBOARD
KB INT(3)
TEST DATA
TEST INSTRUMENTATION AND DATA ACQUISITION INTERFACE SUBSYSTEM
TI INT(4)
STATUS DATA
POSEIDON EVENTS-TRANSLATOR
(MK11.3) STATUS DATA
DTR
FUZE SET DATA
FUZE SET SUBSYSTEM
SERVO POSITION DATA
SERVO ERROR DATA
SERVOS
GUIDANCE DATA
PSC INTERRUPT(5/6)
PARALLEL SERIAL CONVERTER
ALARM/STATUS DATA
COMPUTER PRINTER LOGIC
PROGRAM DATA
COMPUTER TAPE READER LOGIC
20 PPS INTERRUPT(7)
MCTSS

173.349

Figure 4-16.—I/O Section Interface.

building, with each office having a different telephone number.

The units of peripheral equipment with which the DCC communicates also have their own identifying codes. When the DCC must communicate with the peripheral equipment, it sends an external function (EF) code to the I/O section. When the external (peripheral) equipment must communicate with the DCC, the equipment sends an interrupt to the I/O section. The I/O section responds to EF codes and interrupts by notifying the receiving equipment that a data transfer is forthcoming, and then controlling the transfer of data between the DCC and the external equipment. An interrupt causes the DCC to execute an interrupt subprogram to initiate the I/O section operations. Tables 4-3 and 4-4 list the EF codes and the interrupts associated with DCC/external equipment communications.

The data transmitted and received by the DCC is sent over groups of transmission lines referred to as input and output channels. Figure 4-16 illustrates the data channels and the associated external equipment. The control signals, EF codes, and interrupts are not transferred over the input/output data channels; only data words that are to be written into or read from core memory utilize the data channels.

The I/O section can be divided into seven major logic circuits (fig. 4-17):

1. I/O control logic
2. EF sequence control logic
3. Interrupt logic
4. Ready/request and channel control logic
5. Address register logic
6. Interface logic
7. Buffer sequence logic

I/O CONTROL LOGIC.–When an EF instruction is read from memory, the DCC control section enables the EF sequence. The EF sequence timing pulses are sent to the I/O control logic, along with translator function enables from the instruction translator. The I/O control logic then enables the other circuits of the I/O section for an input or output operation.

EF CONTROL LOGIC.–This logic block translates the EF codes into control signals that select the external equipment designated in the EF code and also designates the type of EF operation to be performed. The types of EF operations are:

1. Sense (operational status)
2. Select/activate
3. Condition

The EF control logic controls the O register; the O register holds the EF code that is transmitted to the external equipment.

INTERRUPT LOGIC.–The interrupt logic receives and stores the interrupt signals from the external equipment. The DCC program periodically checks the interrupt logic for the presence of an interrupt request. If an interrupt is present when the DCC program interrogates the interrupt logic, the interrupt logic transmits an interrupt designator word (4 bits) to the DCC control section. The interrupt designator is the address of the first word of a specified interrupt program.

READY/REQUEST AND CHANNEL CONTROL LOGIC.–This logic controls the interchange of control signals between the DCC and the external equipment. These control signals (ready/request) specify the readiness of the equipment involved in the data transfers and enable the transmitting and receiving circuits to begin the input/output operation.

The channel control circuits receive a 3-bit I/O designator word from the DCC control section that designates the input or output channel to be activated. The I/O designator and the channel activate enable an activate channel signal to be transmitted to the external equipment connected to the channel specified by the I/O designator. The signal notifies the equipment that a transmission path is now open. The I/O designator is also translated into a

Table 4-3.—EF Codes

Code		Title
Name	Number	
Internal to DCC	3517	Enable Interrupt 1 (MDF)
	3527	Enable Interrupt 2 (ICL)
	3533	Enable Interrupt 3 (KB)
	3547	Enable Interrupt 4 (TI)
	3553	Enable Interrupt 5 (PSC channel 1)
	3563	Enable Interrupt 6 (PSC channel 2)
	3571	Enable Interrupt 7 (50 Millisecond)
	3572	Enable Interrupt 10 (Buffer Terminate)
	6317	Clear Channel 1 Active (IMPXR)
	6327	Clear Channel 2 Active (OMPXR)
	6333	Clear Channel 3 Active (PSC and TR)
	6347	Clear Channel 4 Active (PSC and PTR)
	6353	Clear Channel 5 Active (KB/ICL)
	6363	Clear Channel 6 Active (KB/ICL)
	5317	Sense Channel 1 Active
	5327	Sense Channel 2 Active
	5333	Sense Channel 3 Active
	5347	Sense Channel 4 Active
	5353	Sense Channel 5 Active
	5363	Sense Channel 6 Active
	3617	Disable Interrupt 1
	3627	Disable Interrupt 2
	3633	Disable Interrupt 3
	3647	Disable Interrupt 4
	3653	Disable Interrupt 5
	3663	Disable Interrupt 6
	3671	Disable Interrupt 7
	3672	Disable Interrupt 10
	0377	Decrease 50-Millisecond Counter
	7760	Sense DCC 1
	5371	Sense Channel 7/8 EF Request
	5372	Sense Arithmetic Overflow
TI Codes	7271	Postlaunch Output
	7272	Spare
	7263	Prelaunch List 2
	7274	Postlaunch Input
	7265	Prelaunch List 1
Printer Reader Codes	31771	Select TR; Activate Input Channel 3
	1772	Sense Printer Availability and Reserve
	41774	Select Printer; Activate Output Channel 4
KB/ICL Codes	7447	Clear DCC 1 (2) Request
	7463	Set DCC 1 (2) Request
	67471	DCC 1 (2) Output Select; Activate Channel 6
	57474	DCC 1 (2) Input Select; Activate Channel 5
	7466	DCC 1 (2) Sense and Reserve ICL
	7465	DCC 1 (2) Sense and Reserve KB
	7455	DCC 1 (2) Sense DCC 2 (1) ICL Start
	7453	DCC 1 (2) Sense DCC 2 (1) ICL Complete
Multiplexer Codes	7721	Sense IMPXR A
	17722	Select IMPXR A; Activate Channel 1
	27724	Select OMPXR A; Activate Channel 2
	7730	Maintenance IMPXR A
	7741	Sense IMPXR B
	17742	Select IMPXR B; Activate Channel 1
	27744	Select OMPXR B; Activate Channel 2
	7750	Maintenance IMPXR B
POSEIDON ET	5517	POSEIDON ET 1 Maintenance Mode
	5527	POSEIDON ET 1 External Clear
	5571	POSEIDON ET 2 Maintenance Mode
	5572	POSEIDON ET 2 External Clear
	4477	ET Maintenance Clear
PSC Codes	6555	DTT Maintenance PSC 1
	6517	PSC Maintenance PSC 1
	6527	Clock Sync Inhibit PSC 1
	6533	Sense MMR or DCR PSC 1
	6535	Data Check Not OK PSC 1
	6563	MMIR PSC 1
	6565	Sense DDR PSC 1
	6571	Data Check OK PSC 1
	66XX	For PSC 2
	6077	PSC External Clear
	6553	Delayed Clock Pulse Maintenance
DTR Clear	5670	Resets all control logic, party line receiver, and pilot register.
Transmit	5607	Enables DCC to broadcast data to DDL.
Start Read	5613	Enables DTR to accept start read word from DCC.
Read	5615	Enables DTR to transfer stored party line data to DCC through DCC input channel 1.
Stop Read	5616	Enables DCC to stop read instruction with intention of restarting it without issuance of a start read word.
Gate Status and Alarm Register	5623	Enables DCC to read contents of DTR Status and Alarm Register (SAR) into DCC.
Load Source Address	5625	Enables DCC to access first five DTR memory locations that store preset words, which contain starting and terminal addresses of each source block in DTR memory.
Gate Terminal Address Register	5626	Enables DCC to read DTR terminal address register into DCC.
Sense DTR	5664	Gates sense return signal to DCC when DTR is connected to the DCC.
Gate Pilot Register	5634	Enables DCC to read contents of DTR pilot register into DCC through DCC input channel 1.
Gate Read/Write Address Register	5645	Enables DCC to read contents of DTR read address generator and write address generator as upper and lower twelve bits respectively into the DCC.
DTR Short Loop	5643	Allows DCC to connect DCC data channels 1 and 2 data and ready/request signals at the DTR read gating logic for testing purposes.

173.356

Table 4-4.—DCC Program Interrupts

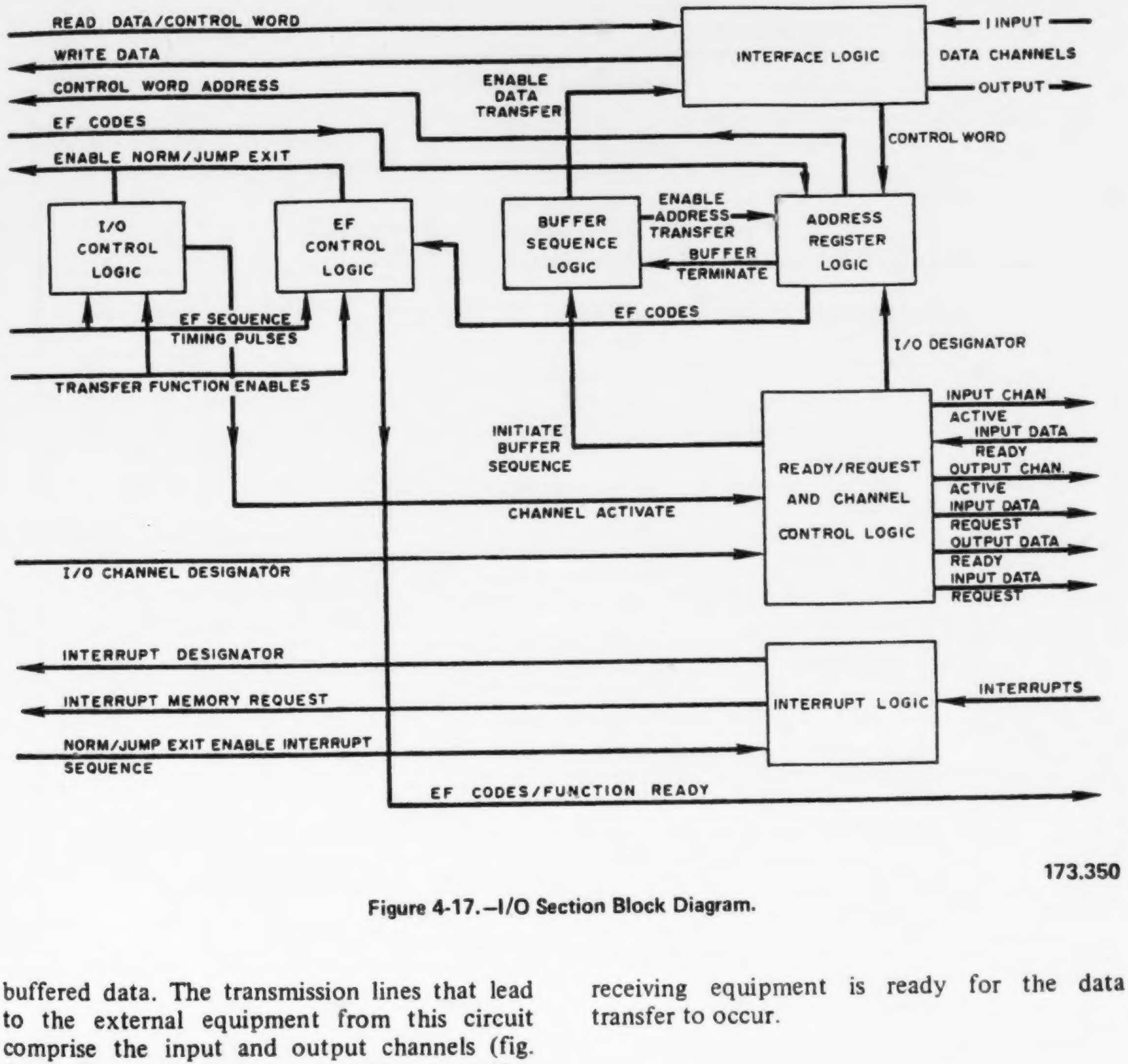
Interrupt	Source	Reason
1	MDF	Notifies DCC when an MDF interrupt word is available on data input channel 7.
2	ICL	Notifies DCC 1(2) when an ICL data transfer is completed with DCC 2(1). Notifies DCC 1(2) when an ICL data transfer is ready to start with DCC 2(1).
3	KB	Notifies DCC that the operator has pressed the ENTER key on the keyboard, making data available to DCC on data input channel 5.
4	TI	Notifies DCC that the TDISS is ready to communicate on data input channel 5 or on data output channel 6.
5	PSC 1	Notifies DCC that a digital data request (DDR) or missile motion request (MMR) has been received from DRISS and that a data transfer is necessary on data I/O channels 3 and 4. Notifies DCC that a data check request (DCR) has been received from DRISS.
6	PSC 2	Same as PSC 1.
7	DRISS (originates in MTA)	Notifies DCC of a 50-millisecond time lapse to establish a time base for various DCC program operations.
10	DCC Channel 1 through 6 Compare	Notifies DCC that a data input channel 1 buffer operation has terminated.

173.349

control word designator. This is sent to the DCC control section to specify the memory address location of the control word that is to be used for the present input/output operation. The control word (CW) is a 24-bit word that specifies the starting address (lower 14 bits) and the terminal address (upper 10 bits) of all the data that is to be read out of or written into memory.

ADDRESS REGISTER LOGIC.—This circuit controls the ADDRESS REGISTERS of the I/O section (fig. 4-18). The address registers provide temporary storage of the address of the input or output data and the terminal address of the data. After each 24-bit word is transferred, the address that it was read from or written into (specified by contents C1 or C2 register) is transferred to the R register (fig. 4-18). The R register increments the address by 1, and then compares the address to the contents of the R1 or R2 registers (terminal address). When the contents of the current and terminal address registers compare, the address register logic translates a buffer terminate signal to indicate that the input/output operation is terminated.

INTERFACE LOGIC.—These circuits provide the path through the I/O section for the


READ DATA/CONTROL WORD
WRITE DATA
CONTROL WORD ADDRESS
EF CODES
ENABLE NORM/JUMP EXIT
INTERFACE LOGIC
INPUT
DATA CHANNELS
OUTPUT
ENABLE DATA TRANSFER
CONTROL WORD
I/O CONTROL LOGIC
EF CONTROL LOGIC
BUFFER SEQUENCE LOGIC
ENABLE ADDRESS TRANSFER
BUFFER TERMINATE
ADDRESS REGISTER LOGIC
EF CODES
EF SEQUENCE TIMING PULSES
TRANSFER FUNCTION ENABLES
I/O DESIGNATOR
INITIATE BUFFER SEQUENCE
READY/REQUEST AND CHANNEL CONTROL LOGIC
INPUT CHAN ACTIVE
INPUT DATA READY
OUTPUT CHAN. ACTIVE
INPUT DATA REQUEST
OUTPUT DATA READY
INPUT DATA REQUEST
CHANNEL ACTIVATE
I/O CHANNEL DESIGNATOR
INTERRUPT DESIGNATOR
INTERRUPT MEMORY REQUEST
INTERRUPT LOGIC
INTERRUPTS
NORM/JUMP EXIT ENABLE INTERRUPT SEQUENCE
EF CODES/FUNCTION READY

173.350

Figure 4-17.—I/O Section Block Diagram.

buffered data. The transmission lines that lead to the external equipment from this circuit comprise the input and output channels (fig. 4-18). The buffer sequence provides the gating signals that transfer the data through the interface logic.

BUFFER SEQUENCE AND CONTROL LOGIC.—The term "buffer" refers to the I/O operation of transmitting or receiving data. The buffer sequence logic generates the enabling signals that gate the data into or out of the DCC I/O section. The buffer sequence logic is initiated by the ready/request logic when the latter has established that the sending or receiving equipment is ready for the data transfer to occur.

COMPUTER PROGRAMS

Computer programs are the software tools that enable the DCC to perform its specialized operations. There are separate programs for arithmetic calculations, transferring input/output data, and controlling the execution of fire control system tests. A program consists of a group of instructions that designates the steps required to execute the program.

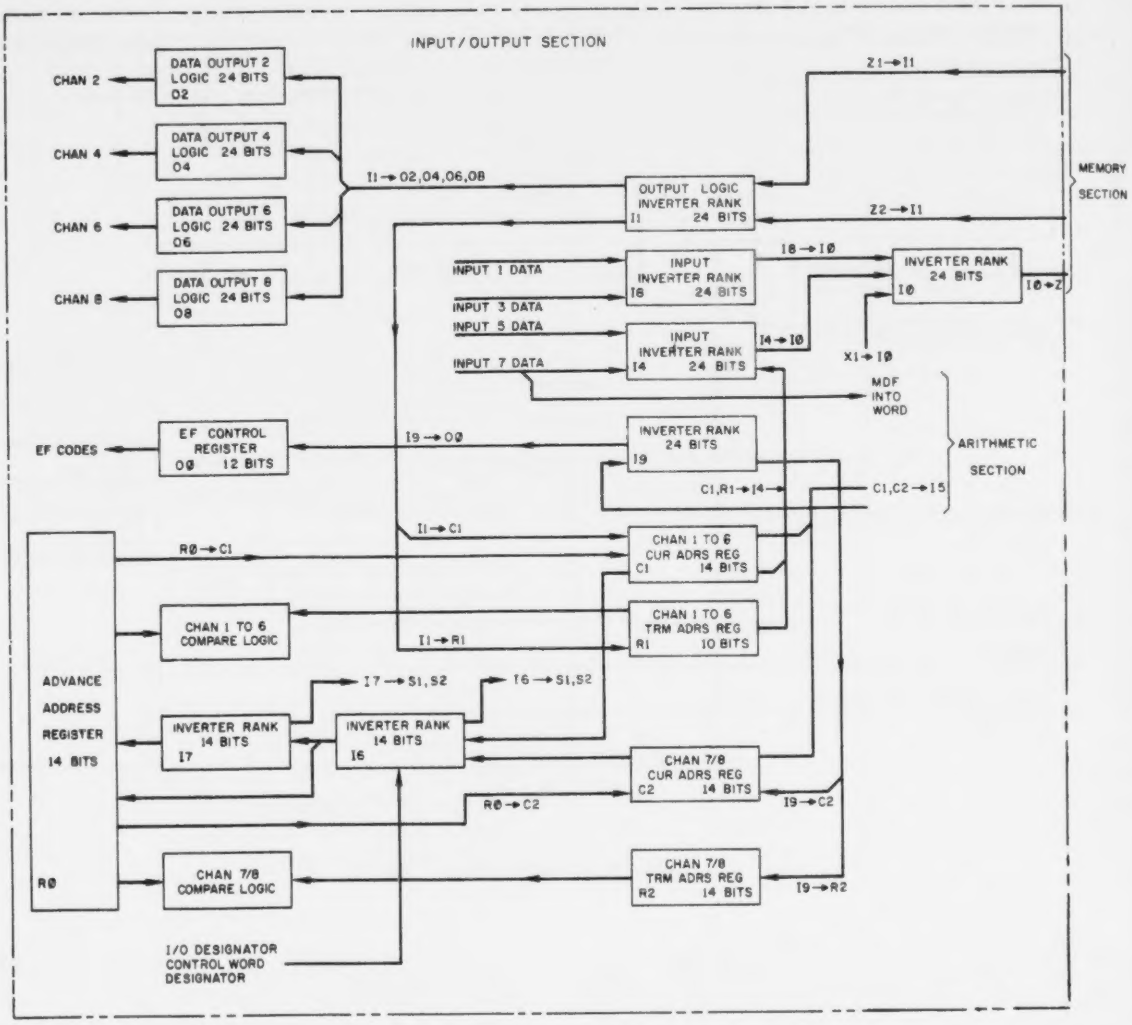

INPUT/OUTPUT SECTION
CHAN 2
DATA OUTPUT 2 LOGIC 24 BITS O2
CHAN 4
DATA OUTPUT 4 LOGIC 24 BITS O4
CHAN 6
DATA OUTPUT 6 LOGIC 24 BITS O6
CHAN 8
DATA OUTPUT 8 LOGIC 24 BITS O8
I1 → O2,O4,O6,O8
Z1 → I1
OUTPUT LOGIC INVERTER RANK I1 24 BITS
Z2 → I1
MEMORY SECTION
INPUT 1 DATA
INPUT 3 DATA
INPUT 5 DATA
INPUT 7 DATA
INPUT INVERTER RANK I8 24 BITS
I8 → I0
INVERTER RANK 24 BITS I0
I0 → Z
INPUT INVERTER RANK I4 24 BITS
I4 → I0
X1 → I0
MDF INTO WORD
EF CODES
EF CONTROL REGISTER O0 12 BITS
I9 → O0
INVERTER RANK 24 BITS I9
ARITHMETIC SECTION
C1,R1 → I4
C1,C2 → I5
I1 → C1
R0 → C1
CHAN 1 TO 6 CUR ADRS REG C1 14 BITS
CHAN 1 TO 6 COMPARE LOGIC
CHAN 1 TO 6 TRM ADRS REG R1 10 BITS
I1 → R1
ADVANCE ADDRESS REGISTER 14 BITS
R0
I7 → S1,S2
I6 → S1,S2
INVERTER RANK 14 BITS I7
INVERTER RANK 14 BITS I6
CHAN 7/8 CUR ADRS REG C2 14 BITS
R0 → C2
I9 → C2
CHAN 7/8 COMPARE LOGIC
CHAN 7/8 TRM ADRS REG R2 14 BITS
I9 → R2
I/O DESIGNATOR CONTROL WORD DESIGNATOR

Figure 4-18.—Address Registers and Interface Logic. 173.351

PROGRAM CATEGORIES

DCC programs can be categorized several different ways: (1) by function; (2) by whether or not the programs are stored in core memory (resident or nonresident); and (3) by whether or not they require the aid of other programs (stand alone or time-shared).

Table 4-5 illustrates various DCC programs and their respective categories. One of the programs provides supervisory control over all other programs. That is the POSEIDON supervisor (PSUP).

PSUP Program

The functions of PSUP are to control the sequencing of other programs, initiate various subprograms, make decisions concerning what subprogram is required to perform a designated

Table 4-5.—Program Categories

	Resident	Non-resident
Stand-alone	POSEIDON supervisor Special Function Programs Resident interrupt routines 1. TI 2. Disk 3. ICL 4. Keyboard 5. Buffer terminate 6. 20 pps Resident print routines 1. Short print 2. Long print Utility Routines 1. Keyboard output request 2. Floating point package 3. Status set and status clear 4. Channel check 5. DCC normal/not normal	ITOP test executive 1. ITOP fire control tests 2. Guidance computer E/A tests 3. Fuze set test 4. MTRE Mk 7 tests 5. GAMET test executive Patrol GAMET Mk 113 target motion analyzer (ASW) program Data entry program (DEP) Base point calculations program (BASC) 1SQ program Training without guidance or dummy fire program (TDUM) Tape read program (TARE) 1. Guidance correction coefficient GUPEL tape read 2. Base calculations results tape read ICL command transfer (TICL) Test instrumentation post launch processor (PLOD) Calibration and update program (CALUP) 1. Patrol update (SFE) 2. Tender (recalibration) update POSEIDON command print (PCMP) Optical alignment group (OAG) executive Wind and density (WNDE) Startup and checkout program (SCP)
Time-shared		SCP called (offline) auxiliary tests SCP diagnostic routines (fault dictionary) Fleet copy program

173.358

task, and control the allocation of memory locations when a task is executed.

Subprograms

A subprogram is that portion of a computer program that performs a computer task. A task is usually comprised of a controlling subprogram (executive routine) and a subprogram that actually executes the task. Some special function programs controlled by PSUP are small enough not to require an executive routine; interrupt routines are an example.

Subprograms can be called up by the operations of PSUP or by the operator through a programming device referred to as the keyboard.

Program Function

Unless a change is sensed in the DCC's operating environment, the program PSUP is constantly cycling. PSUP repeatedly cycles through a series of instructions that sense for any requests for tasks or changes to operating status of the system. When PSUP senses any change to the current status, it calls up a task to either perform a buffer or a calculation.

Program and Data Storage

Resident programs are those programs originally bootstrapped into core memory. Nonresident programs remain stored on an MDF until called up by PSUP. A few nonresident computer routines are also stored on punched tape.

MDF.–The magnetic disk file, to be covered later in this chapter in detail, is a memory storage device that is utilized to supplement the storage capabilities of the DCC core memory. The MDF has a storage capacity of approximately two million 25-bit words.

The element of the magnetic disk file that has all POSEIDON programs (resident and nonresident) recorded on it is referred to as the disk pack. The disk pack consists of twenty recordable surfaces with 100 recording tracks per surface. Figure 4-19 depicts the allocation of the data assigned to a POSEIDON disk pack.

Data can be written onto or read from the MDF only through the operation of the DCC via I/O channels 7 and 8. Programs from the MDF can be called up by the DCC in one of three ways:

1. Response to a keyboard entry by the operator.
2. Automatically, as a function of a resident program.
3. Bootstrap operation.

PROGRAM DATA PROTECTION.–Most of the data recorded in DCC core memory and on the disk pack is protected from deliberate and accidental alteration.

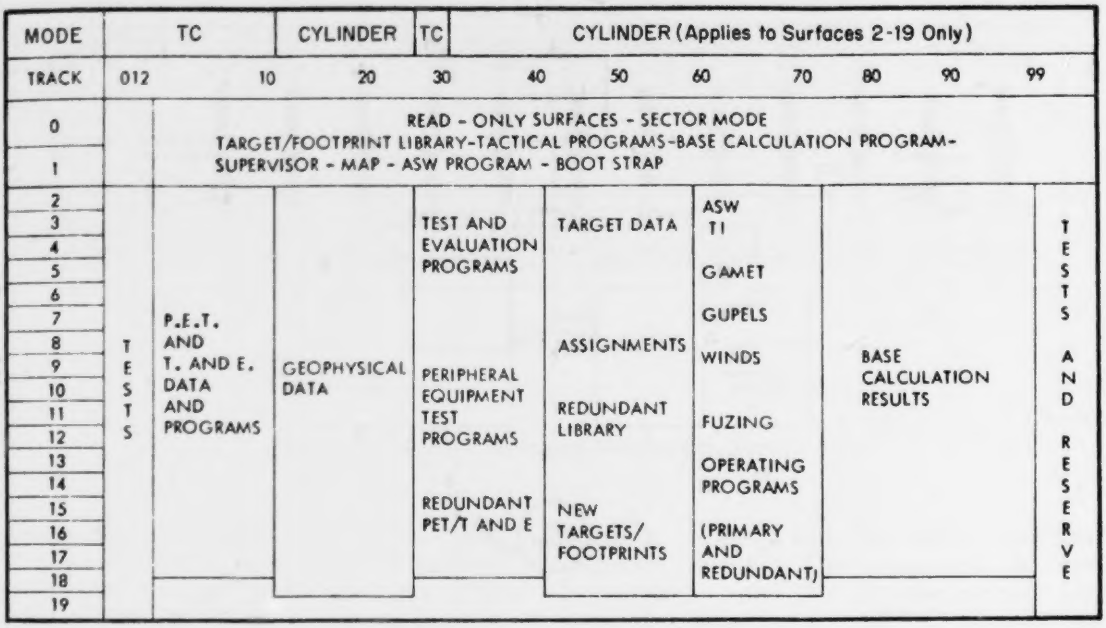
Figure 4-20 illustrates the key operated interlock switches that prevent new data from being written over the data presently stored on the disk pack and the core memory. As illustrated, both memory devices contain storage allocations that are not protected; these areas are not affected by operated switches. Operation of the key to the nonprotect position could, of course, allow the otherwise protected areas to be altered.

The MDF has an extra protective feature (figs. 4-19 and 4-20); the 0 and 1 surfaces of the disk pack are READ ONLY, a characteristic of circuit design.

DCC-ECDC

The Mk 88 Mod 1 POSEIDON Fire Control System incorporates two DCCs. These interface with peripheral equipment for receiving updated data and to transmit data to other equipment and subsystems of the fire control system. There are some units of equipment that are duplicated in the same manner as the DCCs within the fire control system. Figure 4-1 illustrates these duplicated units of equipment.

The duplicated peripheral equipment can be cross-connected to either one or both DCCs, or may be isolated completely. The various peripheral equipments are connected by the operator to the DCC through remote-controlled


MODE
TC
CYLINDER
TC
CYLINDER (Applies to Surfaces 2-19 Only)
TRACK
012
10
20
30
40
50
60
70
80
90
99
0
1
READ - ONLY SURFACES - SECTOR MODE
TARGET/FOOTPRINT LIBRARY-TACTICAL PROGRAMS-BASE CALCULATION PROGRAM-
SUPERVISOR - MAP - ASW PROGRAM - BOOT STRAP
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
SURFACES
TESTS
P.E.T. AND T. AND E. DATA AND PROGRAMS
GEOPHYSICAL DATA
TEST AND EVALUATION PROGRAMS
PERIPHERAL EQUIPMENT TEST PROGRAMS
REDUNDANT PET/T AND E
TARGET DATA
ASSIGNMENTS
REDUNDANT LIBRARY
NEW TARGETS/ FOOTPRINTS
ASW TI
GAMET
GUPELS
WINDS
FUZING
OPERATING PROGRAMS
(PRIMARY AND REDUNDANT)
BASE CALCULATION RESULTS
TESTS AND RESERVE

173.352

Figure 4-19.—Disk Pack Data Storage.

switches referred to as configuration switches (with the exception of the MDFs, which are connected by means of plug-ins at a patch panel). The switches are controlled from an Equipment Configuration Display and Control (ECDC) panel. The panel, located above the Fire Control Console, also provides a pictorial display of the connections between the DCC and peripheral equipment.

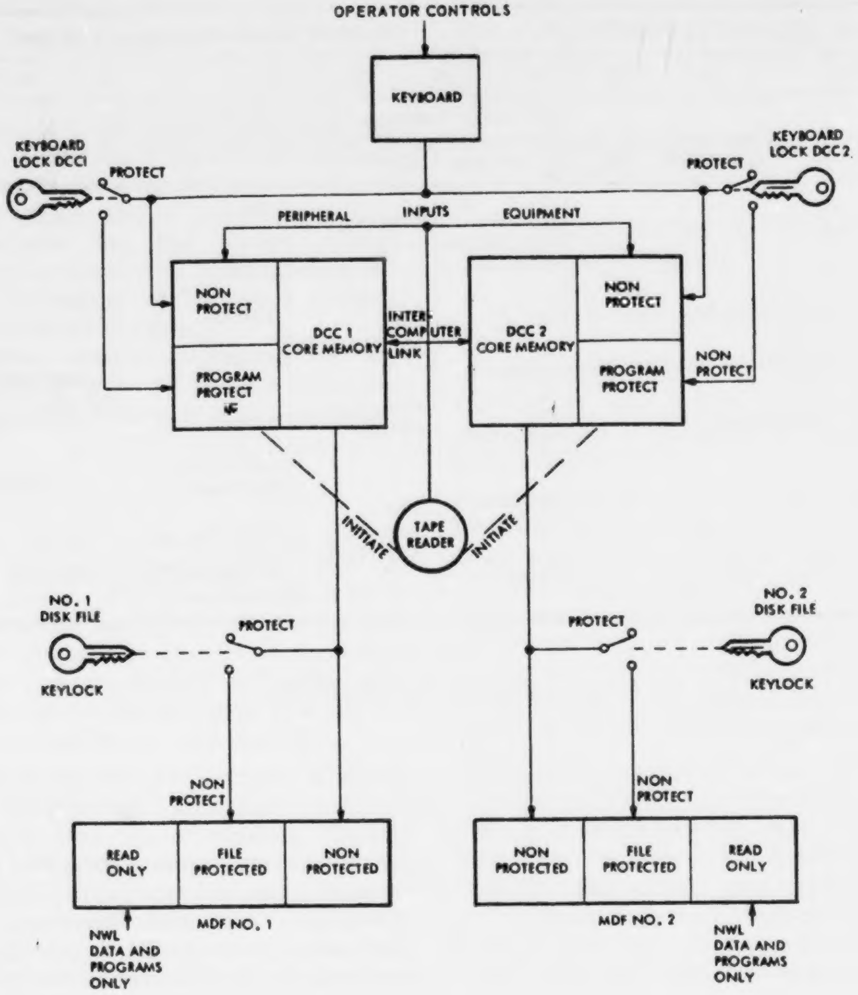
Figure 4-21 depicts the displays and pushbuttons that control the switching on the ECDC panel. The panel controls the positioning of nine groups of configuration switches and displays the DCC to equipment configuration of eleven equipment groups. The MDFs are displayed but not controlled by the panel. The equipment that comprises each switch group is depicted in figure 4-22.

FUNCTIONAL DESCRIPTION

Connection of a particular piece of equipment to a DCC is accomplished in the following manner: The DCC is selected by the operator depressing the appropriate DCC SELECT pushbutton. (If both DCC SELECT pushbuttons are depressed, the first pushbutton depressed has priority.) The DCC SELECT pushbutton is held depressed, and the pushbutton for the equipment to be connected is depressed; the equipment select pushbutton is released first, and then the DCC SELECT pushbutton is released. The selected equipment is now commanded but not yet switched to the DCC. The ENTER pushbutton is then depressed, and the commanded switches roll to the appropriate DCC. In a similar manner, the other equipment is connected to one DCC or the other.

When an equipment select pushbutton alone is depressed, the equipment associated with that pushbutton is commanded to be disconnected from the DCC. Depressing the ENTER pushbutton rolls the switches OFF.

The two DCC select indicators on the left of the panel indicate DCC status. Either indicator


OPERATOR CONTROLS
KEYBOARD
KEYBOARD LOCK DCC1
PROTECT
KEYBOARD LOCK DCC2
PROTECT
PERIPHERAL
INPUTS
EQUIPMENT
NON PROTECT
DCC 1 CORE MEMORY
PROGRAM PROTECT
INTER-COMPUTER LINK
DCC 2 CORE MEMORY
NON PROTECT
PROGRAM PROTECT
NON PROTECT
INITIATE
TAPE READER
INITIATE
NO. 1 DISK FILE
KEYLOCK
PROTECT
NO. 2 DISK FILE
KEYLOCK
PROTECT
NON PROTECT
NON PROTECT
READ ONLY
FILE PROTECTED
NON PROTECTED
MDF NO. 1
NON PROTECTED
FILE PROTECTED
READ ONLY
MDF NO. 2
NWL DATA AND PROGRAMS ONLY
NWL DATA AND PROGRAMS ONLY

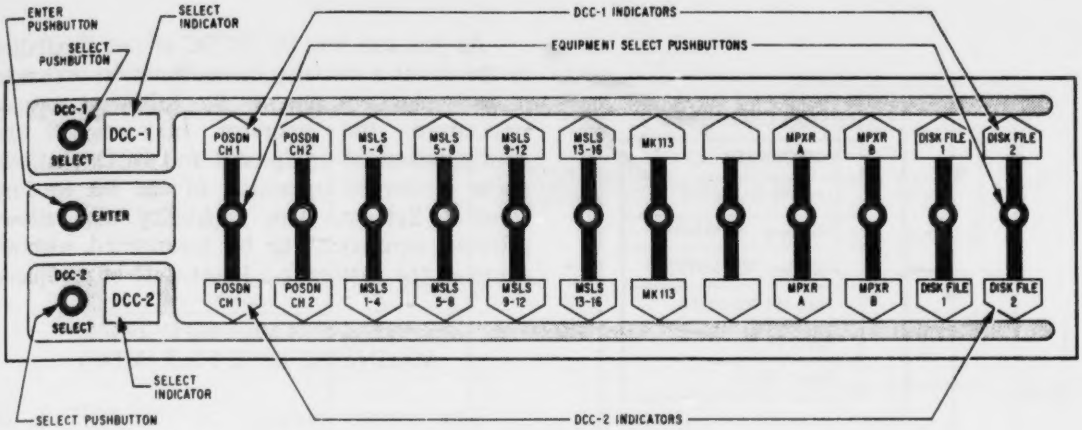
173.353

Figure 4-20.—Data Input Protective Features.

may be green, red, or out. A green light indicates that the DCC is connected and operating normally. A red light indicates a condition other than normal, such as an alarm. If the DCC is not connected to the Digital Transmitter-Receiver (DTR) or one of the two POSEIDON channels, the indicator is out.

Each of the 11 equipment groups has two indicators that show whether the equipment is connected to DCC1 or DCC2. With the exception of the two MDF indicators which may be green or out only, each indicator may be out, green, red, or yellow. To understand the different indications, consider the following examples:

An equipment is commanded to DCC1 by an operator pushing the DCC1 SELECT pushbutton and an equipment select pushbutton as previously described. The indicator for that equipment becomes red, showing that the


ENTER PUSHBUTTON
SELECT INDICATOR
SELECT PUSHBUTTON
DCC-1 INDICATORS
EQUIPMENT SELECT PUSHBUTTONS
DCC-1
SELECT
DCC-1
ENTER
DCC-2
SELECT
DCC-2
POSDN CH 1
POSDN CH 2
MSLS 1-4
MSLS 5-8
MSLS 9-12
MSLS 13-16
MK 113
MPXR A
MPXR B
DISK FILE 1
DISK FILE 2
SELECT INDICATOR
SELECT PUSHBUTTON
DCC-2 INDICATORS

173.426

Figure 4-21.—DCC to Equipment Configuration Panel.

equipment has been commanded to DCC1. The ENTER pushbutton is then depressed and the switches roll to the DCC1 position. The equipment indicator becomes green, showing that it has been switched successfully. If this equipment were connected to DCC2 properly, a similar sequence would have been observed on the equipment indicator for DCC2. If the switches fail to roll properly to the DCC1 or DCC2 position, the appropriate indicator remains red after the ENTER pushbutton is depressed.

Assume now that the equipment is connected to DCC1, and it is desired to disconnect it. The DCC1 equipment indicator is green. The equipment is commanded to off by the operator pushing the equipment select pushbutton. Both the DCC1 and DCC2 equipment indicators become yellow. Depressing the ENTER pushbutton causes the switches to roll to off, and both indicators go out when the switches have rolled properly. The indicators will remain yellow if the switches failed to roll as commanded.

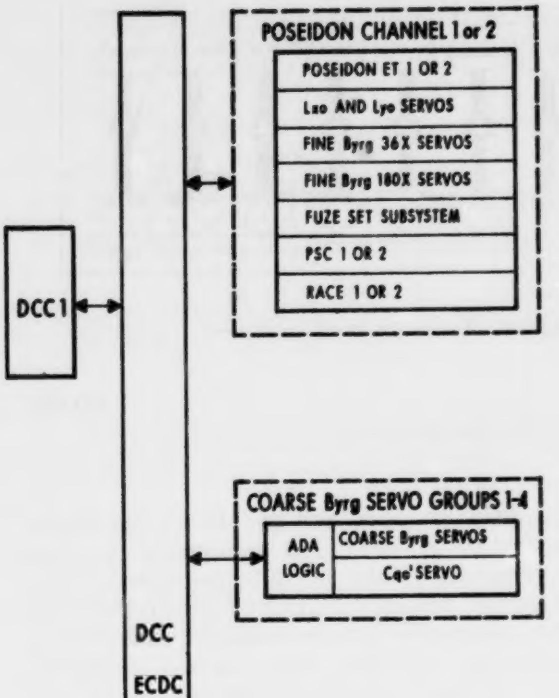
An equipment may also be switched from one DCC directly to the other DCC; for example, from DCC1 to DCC2. Before the switching takes place, the DCC1 equipment indicator is green and the DCC2 equipment indicator is out. The equipment is then commanded to the DCC2 by the operator who depresses the DCC2 SELECT pushbutton and the appropriate equipment select pushbutton as previously described. DCC1 is still connected, but the DCC1 equipment indicator is out and the DCC2 equipment indicator is red. The ENTER pushbutton is then depressed and the switches roll. The DCC2 equipment indicator now becomes green.

The MDF indicators located on the configuration panel are either green or out. The green indicator occurs when the MDF is connected to a particular DCC. The MDF indicator for the DCC that is not connected is out. The DCC-MDF patch panel (see fig. 4-24) is arranged so that it is physically impossible to have two DCCs connected to the same MDF.

It is possible for a single DCC to be assigned to all of the equipment groups listed, with two exceptions:

1. Both multiplexers cannot be connected to the same DCC at one time, and conversely.

2. Both MDFs cannot be connected to the same DCC at one time, and conversely.


POSEIDON CHANNEL 1 or 2
POSEIDON ET 1 OR 2
Lzo AND Lyo SERVOS
FINE Byrg 36X SERVOS
FINE Byrg 180X SERVOS
FUZE SET SUBSYSTEM
PSC 1 OR 2
RACE 1 OR 2
DCC 1
COARSE Byrg SERVO GROUPS 1-4
ADA LOGIC
COARSE Byrg SERVOS
Cqo' SERVO
DCC
ECDC
MULTIPLEXERS
INPUT/OUTPUT MULTIPLEXER A
INPUT/OUTPUT MULTIPLEXER B
DCC 2
MAGNETIC DISK FILE 1 or 2
DIGITAL TRANSMITTER RECEIVER

173.427

Figure 4-22.—DCC-ECDC Interface.

As you can see, the ECDC allows flexibility in the event a casualty or malfunction occurs to a particular equipment. By following proper procedure, the operator may select the configuration of equipment and DCCs that will allow continued operation of the Mk 88 Fire Control System. This capability also allows selected equipment to be maintained without bringing the system to a lesser state of readiness.

MAGNETIC DISK FILE (MDF)

The overall purpose of the MDF is to provide storage for digital data required for DCC computations. The MDF has a storage capacity of 2.25 million 25-bit words and has the capability of reading these words from storage at a rate of 28,000 words per second.

The type of data that is stored by the MDF as a component of the Mk 88 POSEIDON Fire Control System is illustrated in figure 4-19. This section will familiarize you with how the MDF stores and retrieves the data.

GENERAL DESCRIPTION

The MDF equipment (fig. 4-23) is comprised of the following major assemblies:

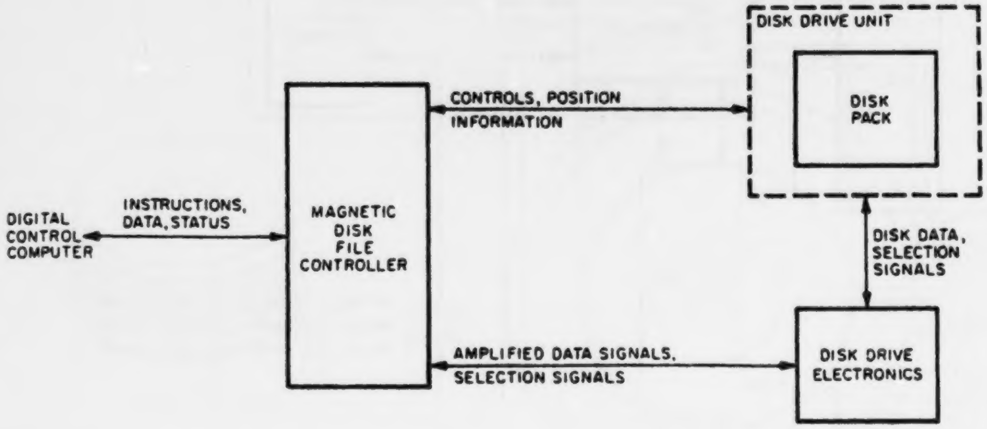
1. Disk Pack
2. Disk Drive Unit (DDU)
3. MDF Controller

Disk Pack

The disk pack is the data storage device of the MDF. It is installed in the DDU. It can be installed or removed from the DDU in a manner similar to placing records on a phonograph. Information is placed on the disk pack as 25-bit words made up of binary 1s and 0s.

Disk Drive Unit (DDU)

The DDU is the assembly in which the disk pack is installed for operation. The DDU rotates the disk pack and positions the devices that magnetically place and retrieve the data on the disk surfaces.


DIGITAL CONTROL COMPUTER
INSTRUCTIONS, DATA, STATUS
MAGNETIC DISK FILE CONTROLLER
CONTROLS, POSITION INFORMATION
DISK DRIVE UNIT
DISK PACK
DISK DATA, SELECTION SIGNALS
AMPLIFIED DATA SIGNALS, SELECTION SIGNALS
DISK DRIVE ELECTRONICS

173.359

Figure 4-23.—MDF Block Diagram.

MDF Controller

The controller includes those logic circuits that control the data transfers between the MDF and the DCC as well as the sequence of steps required to execute the various types of MDF operations.

MDF-DCC Configuration

The Mk 88 Mod 1 POSEIDON Fire Control System incorporates two MDFs labeled MDF1 and MDF2. One MDF may be manually cross-connected to one or the other of the two DCCs of the fire control system (fig. 4-24). This switching capability again gives us flexibility and continued operation in the event of a casualty to one of the MDFs so that we may maintain a maximum firing rate of the system.

In addition, the DDUs may also be casualty switched to operate in conjunction with one or the other MDF controllers. The cross-connecting is performed by swapping the interconnecting cables between the various units. The actual switching of the cables is performed by an FTB at a central patch panel. The plugs attached to the cables are manually inserted into designated receptacles to complete a connection between the units for the desired configuration.

The normal configuration would be DCC1 - MDF1 - DDU1 and DCC2 - MDF2 - DDU2.

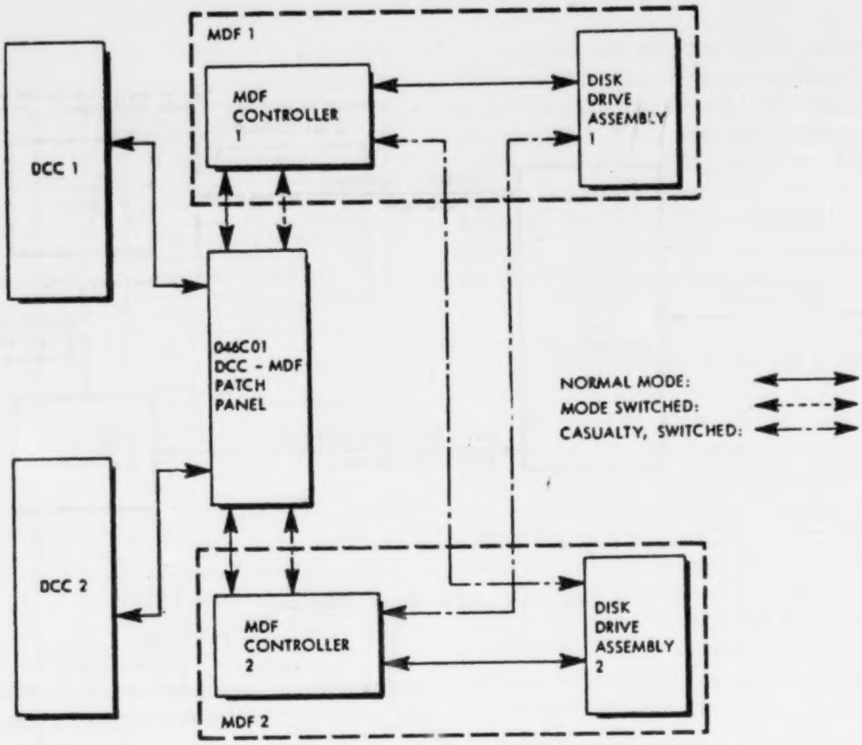
FUNCTIONAL DESCRIPTION

The MDF accomplishes its purpose through the three major assemblies just described generally. The following pages will discuss the function and operation of those assemblies individually and place each assembly in its proper place in the overall function of the MDF.

Disk Pack

The disk pack assembly (fig. 4-25) is comprised of eleven disks assembled in parallel on a common hub. Both sides of each disk are coated with a magnetic material. The upper surface of the top disk and the lower surface of the bottom disk are not available for recording. Therefore, twenty disk surfaces, numbered 00 through 19, are available.

After the disk pack is installed in the DDU, data may be electromechanically read from or written onto the disk surfaces by means of



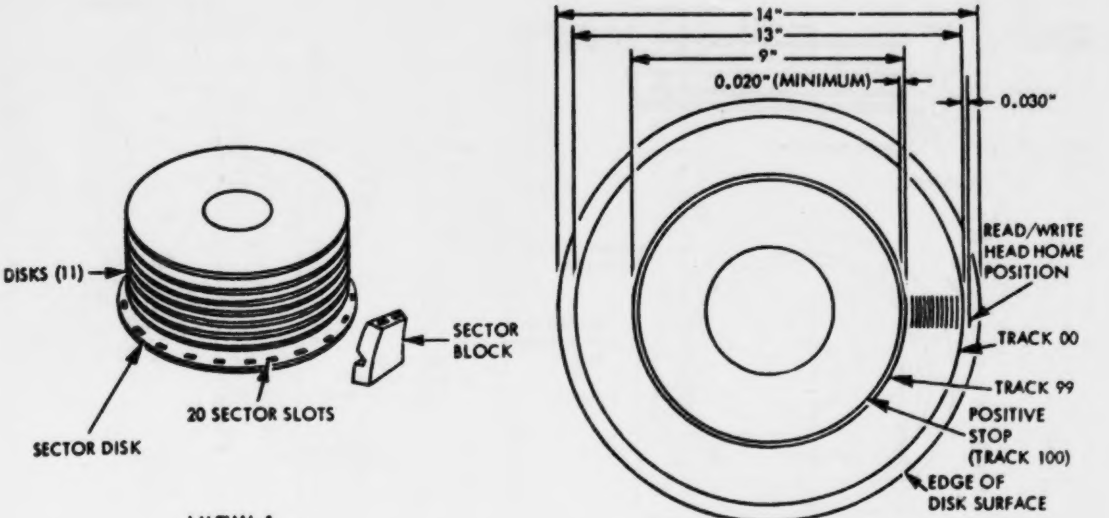
173.360

Figure 4-24.—DCC-MDF Configuration.

devices called read/write heads. There is a total of twenty heads, 00 through 19; one for each disk surface. Only one head will be enabled at a time, either to read or to write.

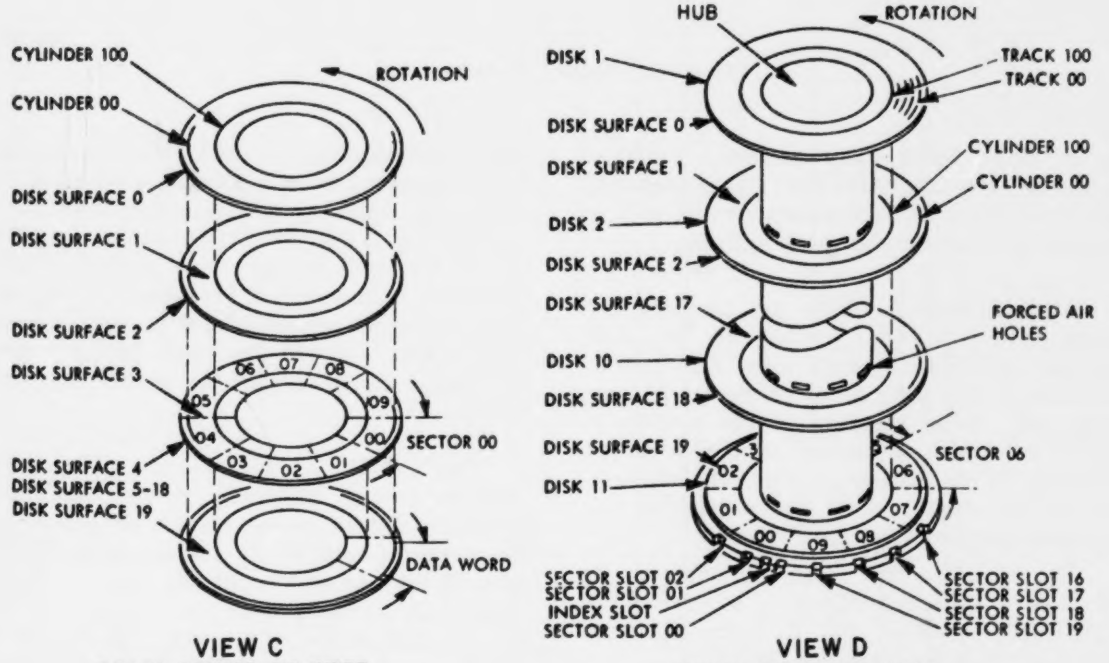
When data is being placed on the disk surfaces for the first time, the disk pack will be rotating, and the narrow bands of disk surface area will be passing beneath each read/write head. These narrow bands will be magnetically imprinted with bits of data. During the course of placing data on the disk surface, the read/write head will be placed at 101 different positions with respect to the disk surface, and consequently there will be 101 narrow bands of disk surface area that correspond to the head positions. These areas are called TRACKS (fig. 4-25). There is one additional position of the head with respect to the disk surface where no data is recorded. This is called the HOME position and is located near the outer edge of the disk.

The bottom disk in each pack is a round plate called the SECTOR DISK. This disk has twenty slots evenly spaced around the outer edge called sector slots. In addition, there is another slot called the INDEX slot placed near one of the sector slots. The sector slots are used to divide the disk surfaces into ten recording areas or SECTORS. The sectors are labeled 00 through 09. The INDEX slot is used to define sector 00 and also to establish the start of a track. The slots pass through a light beam as the disk rotates. The light beam path is allowed to reach a photocell because of the opening provided by the sector slots (fig. 4-26). The light source and photocell assembly is called the


DISKS (11)
SECTOR BLOCK
20 SECTOR SLOTS
SECTOR DISK
14"
13"
9"
0.020" (MINIMUM)
0.030"
READ/WRITE HEAD HOME POSITION
TRACK 00
TRACK 99
POSITIVE STOP (TRACK 100)
EDGE OF DISK SURFACE

VIEW A
DISK ARRANGEMENT

VIEW B
DISK TRACK ARRANGEMENT

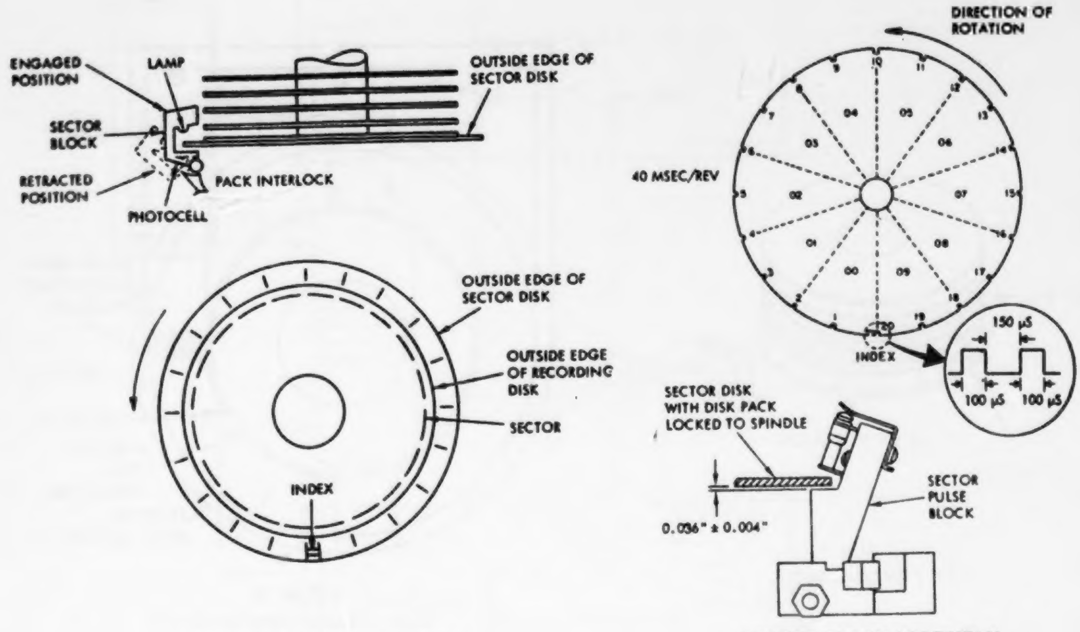

CYLINDER 100
CYLINDER 00
ROTATION
DISK SURFACE 0
DISK SURFACE 1
DISK SURFACE 2
DISK SURFACE 3
06
07
08
05
09
04
00
03
02
01
SECTOR 00
DISK SURFACE 4
DISK SURFACE 5-18
DISK SURFACE 19
DATA WORD
HUB
ROTATION
DISK 1
TRACK 100
TRACK 00
DISK SURFACE 0
CYLINDER 100
DISK SURFACE 1
CYLINDER 00
DISK 2
DISK SURFACE 2
DISK SURFACE 17
FORCED AIR HOLES
DISK 10
DISK SURFACE 18
DISK SURFACE 19
SECTOR 06
DISK 11
02
06
01
07
00
09
08
SECTOR SLOT 02
SECTOR SLOT 01
INDEX SLOT
SECTOR SLOT 00
SECTOR SLOT 16
SECTOR SLOT 17
SECTOR SLOT 18
SECTOR SLOT 19

VIEW C
TRACK, SECTOR, CYLINDER
AND WORD ARRANGEMENT

VIEW D
TRACK, SECTOR, CYLINDER
AND SECTOR ARRANGEMENT

173.361

Figure 4-25.—Disk Pack Arrangement.


ENGAGED POSITION
LAMP
OUTSIDE EDGE OF SECTOR DISK
SECTOR BLOCK
RETRACTED POSITION
PACK INTERLOCK
PHOTOCELL
OUTSIDE EDGE OF SECTOR DISK
OUTSIDE EDGE OF RECORDING DISK
SECTOR
INDEX
DIRECTION OF ROTATION
40 MSEC/REV
INDEX
150 µS
100 µS
100 µS
SECTOR DISK WITH DISK PACK LOCKED TO SPINDLE
SECTOR PULSE BLOCK
0.036" ± 0.004"

SECTOR DISK ARRANGEMENT

SECTOR BLOCK ASSEMBLY

173.362

Figure 4-26.—Sector Disk Arrangement.

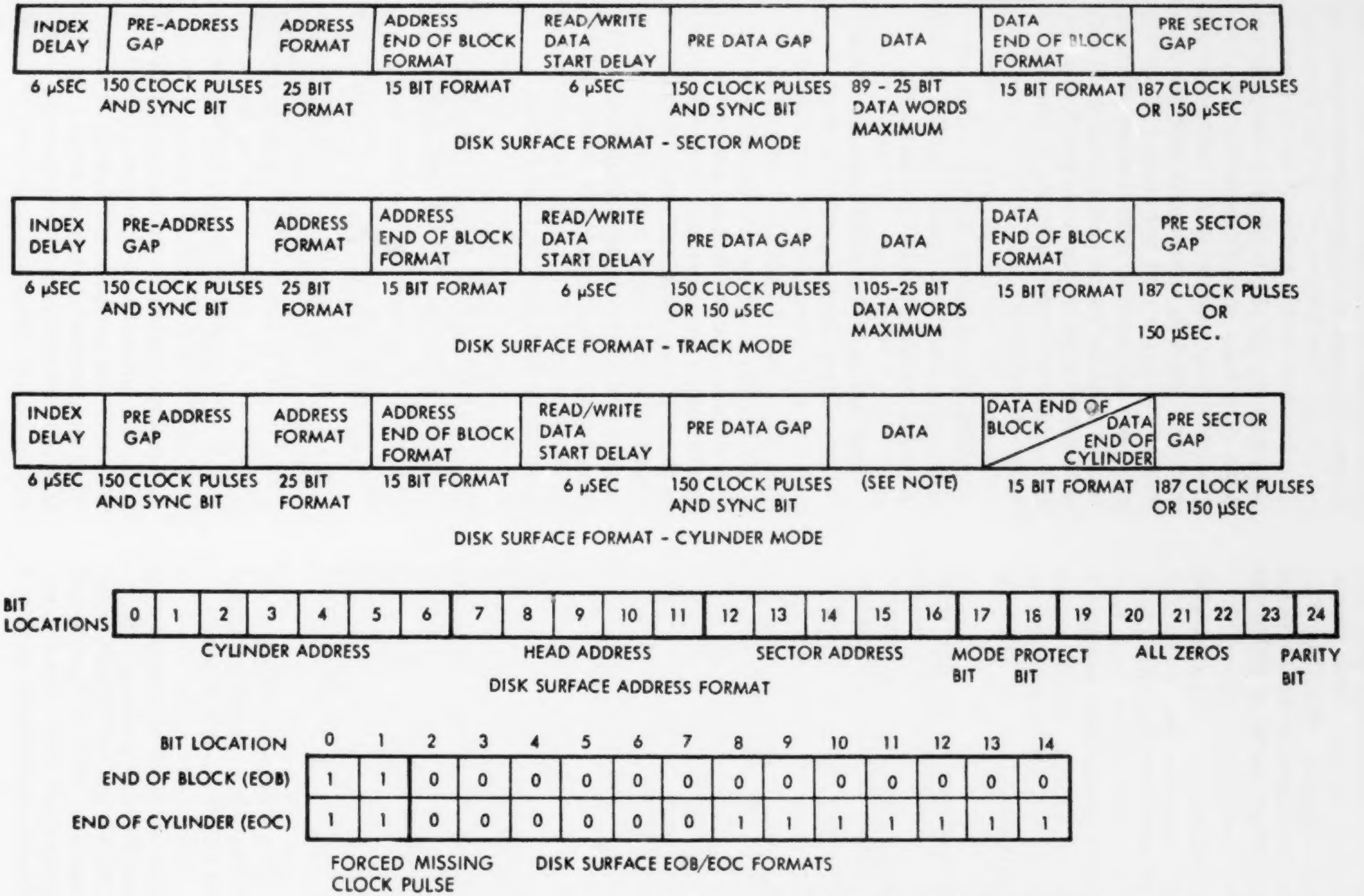
sector pulse block. This assembly generates pulses to notify the MDF logic of the beginning of a sector or track. The pulses are also used to monitor the speed of disk pack rotation.

DISK FORMAT.—There are basically two types of information written on the disk, address information and data information. Associated with both types are timing bits and code bits. When speaking of the manner in which the disk is formatted, we are, in reality, referring to the manner in which the addresses are written on the disk. Address writing is a separate operation from data writing.

The operation that places the addresses on the disk is logically referred to as the WRITE ADDRESS operation and it is this operation that establishes the format of the disk.

There are two types of disk surface formats, figure 4-27, the TRACK format and the SECTOR format. A format operation is performed on only one track at a time, but the same numbered track is formatted on all of the disk surfaces during the formatting operation. A formatting (WRITE ADDRESS) operation begins with disk surface 00 (or surface 02) and continues to disk surface 19; therefore, whatever type of format was used for a specified track on surface 00 will also be used for that same numbered track on all the surfaces through surface 19.

The TRACK format has one address only. This is at the beginning of the track. The SECTOR format has an address written at the beginning of each of the ten sectors along the given track. As was previously mentioned, the sectors are established by the relative locations of the slots in the sector disk. The manner in which a track is formatted will establish how many data words can be written on any given track (fig. 4-27). Since the sector format requires more track area for writing addresses,



INDEX DELAY	PRE-ADDRESS GAP	ADDRESS FORMAT	ADDRESS END OF BLOCK FORMAT	READ/WRITE DATA START DELAY	PRE DATA GAP	DATA	DATA END OF BLOCK FORMAT	PRE SECTOR GAP
6 μSEC	150 CLOCK PULSES AND SYNC BIT	25 BIT FORMAT	15 BIT FORMAT	6 μSEC	150 CLOCK PULSES AND SYNC BIT	89 - 25 BIT DATA WORDS MAXIMUM	15 BIT FORMAT	187 CLOCK PULSES OR 150 μSEC

DISK SURFACE FORMAT - SECTOR MODE

INDEX DELAY	PRE-ADDRESS GAP	ADDRESS FORMAT	ADDRESS END OF BLOCK FORMAT	READ/WRITE DATA START DELAY	PRE DATA GAP	DATA	DATA END OF BLOCK FORMAT	PRE SECTOR GAP
6 μSEC	150 CLOCK PULSES AND SYNC BIT	25 BIT FORMAT	15 BIT FORMAT	6 μSEC	150 CLOCK PULSES OR 150 μSEC	1105-25 BIT DATA WORDS MAXIMUM	15 BIT FORMAT	187 CLOCK PULSES OR 150 μSEC.

DISK SURFACE FORMAT - TRACK MODE

INDEX DELAY	PRE ADDRESS GAP	ADDRESS FORMAT	ADDRESS END OF BLOCK FORMAT	READ/WRITE DATA START DELAY	PRE DATA GAP	DATA	DATA END OF BLOCK / DATA END OF CYLINDER	PRE SECTOR GAP
6 μSEC	150 CLOCK PULSES AND SYNC BIT	25 BIT FORMAT	15 BIT FORMAT	6 μSEC	150 CLOCK PULSES AND SYNC BIT	(SEE NOTE)	15 BIT FORMAT	187 CLOCK PULSES OR 150 μSEC

DISK SURFACE FORMAT - CYLINDER MODE

BIT LOCATIONS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

CYLINDER ADDRESS HEAD ADDRESS SECTOR ADDRESS MODE BIT PROTECT BIT ALL ZEROS PARITY BIT

DISK SURFACE ADDRESS FORMAT

BIT LOCATION	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
END OF BLOCK (EOB)	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
END OF CYLINDER (EOC)	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1

FORCED MISSING CLOCK PULSE

DISK SURFACE EOB/EOC FORMATS

NOTE: 89-25 BIT DATA WORDS MAXIMUM PER SECTOR (17,800-25 BIT WORDS MAXIMUM PER CYLINDER) IN SECTOR-CYLINDER MODE.
1105-25 BIT DATA WORDS MAXIMUM PER TRACK (22, 100-25 BIT WORDS PER CYLINDER) IN TRACK-CYLINDER MODE.
TOTAL NUMBER OF DATA WORDS FOR EITHER MODE IS DETERMINED BY THE NUMBER OF WORDS TO BE TRANSFERRED DURING THE MDF OPERATION.

173.363

Figure 4-27.—Disk Surface Format.

there will be less room for writing data than there is with the track format. Track format allows room for a maximum of 1105 25-bit data words, .while the sector format allows room for only 89 words per sector or a total of 890 words per track.

Once the disk formatting operation has been performed, a WRITE operation can be executed to place the data on the disk surface. After both the address and data information have been written on the disk, a given track will have a format similar to the TRACK MODE format illustrated in figure 4-27, or the tracks will have ten identical formats similar to the SECTOR MODE example.

Any information written on the disk must be placed there in a manner that will facilitate retrieving (reading) the data efficiently. Therefore, the format of the information written on the disk will include the following information (fig. 4-27).

Pre-Address Gap.–The beginning of the pre-address gap (fig. 4-27) starts at a point immediately following a short space on the track that is devoid of data. This space represents the time that will elapse between the sensing of the INDEX slot of the sector disk and the activation of the write circuits to write the first clock pulse of the pre-address gap. This time elapse has a nominal value of 6 microseconds. The pre-address gap is comprised of 150 clock pulses and one SYNC BIT. The terms clocks and bits will be used to differentiate between clock bits and data bits for the remainder of the chapter. The 150 clock pulses are used during a read operation to generate control signals within the MDF controller that enable the disable circuits in preparation for reading the address bits that are to follow.

The sync bit occurs after the 150th clock pulse and indicates that the next data bit that is read will be the first bit of the address word.

Address Format.–These 25 bits identify the location of the space the address occupies on the disk surface. The address format bits specify the track (cylinder address), disk surface (head address), and sector on which they were written. The mode bit indicates whether this address is the beginning of a track format or a sector format. The protect bit establishes whether or not the data that follows will require operation of an interlock switch before it can be changed. The parity bit (bit 24) is a logic 1 when the sum of the other logic 1s in the address word is even (odd parity). As each bit of the address word is written on the disk, a clock pulse will be written with it. During the read operation, both a clock pulse and an address data bit are retrieved together. The clocks are used to enable the data bit to be detected by the read/write logic in the MDF controller and to provide the timing for the read operation.

ADDRESS END-OF-BLOCK.–This is a 15-bit code word that signals the MDF control logic of the end of the address information.

PRE-DATA GAP AND DATA START DELAY.–These bits provide the same basic functions as the pre-address gap and index delay.

DATA BITS.–These bits are in the form of 25-bit words. The number of words written in the designated data area of a track will depend on the mode in which the write operation was performed. A sector mode will allow a maximum of 89 words for each designated data space within each sector; the track mode allows for a maximum of 1105 words to be written in the designated space of the track format.

A clock pulse is written with each data bit just as with the address format. The purpose of the clocks is the same for the data as it was for the address.

Data End-of-Block.–The data EOB is the same type of code used to indicate the end of an address block. The End-of-Cylinder (EOC) code is used in this position of the format to indicate the end of disk surface recording space. The EOC is used instead of the EOB when the disk surface involved is surface 19.

Clock pulses are written with the EOB and EOC code bits just as with the address and data bits, with one slight modification. The clock that should occur between the second and third EOB/EOC bits will be inhibited when the code is written on the disk. This is the way the MDF logic detects that the information being read is an EOB or EOC code, and not data or an address (see fig. 4-27).

Pre-Sector Gap.–The slots in the disk pack sector disk are sensed by two photocells called the pre-sector and sector photocells. A pre-sector pulse is generated to notify the MDF write logic that the end of a sector or a track is near. This pulse notifies the write circuitry that only 150 microseconds are left before the sector photocell will sense the slot which defines the end of a sector or track. The occurrence of the pre-sector pulse establishes the beginning of the pre-sector gap area (fig. 4-27) of the disk surface format. When the pre-sector pulse occurs, the MDF write logic allows any word being written to be completed and then forces an EOB code to be written at the end. Any further write operations on that track will then be inhibited for the duration of the pre-sector gap.

CYLINDER CONCEPT.–All read/write heads are positioned in unison. For example, if head 00 is commanded to track 50 on disk surface 00, all of the remaining heads are also positioned at track 50 relative to their own disk surfaces. If a line were drawn vertically through each disk surface, passing through the same track of every surface, and were rotated 360° around the disk axis, a cylinder would be formed. It is from this concept that the term CYLINDER is derived. It is standard procedure to refer to the position of the read/write head, with respect to the disk surfaces, in terms of a cylinder position (fig. 4-25), rather than to state it as a track position. The term track will still be used, but only to denote an operation that applies to one specific disk surface. The term cylinder will be used in connection with a single read/write operation that continues from one disk surface to another.

CYLINDER 100.–This cylinder is referred to as the maintenance cylinder. It is used as a scratch pad (just as we would use a scratch pad in calculating some mathematical problem) to check out the read/write logic of the MDF. It is only used for maintenance purposes, and no tactical data is stored on any of the cylinder 100 tracks on any of the disk surfaces.

Disk Drive Unit (DDU)

The DDU contains the devices that mechanize the read and write operations. It also houses and drives the disk pack (fig. 4-28).

The major components of the DDU are as follows:

1. Disk pack drive system
2. Head carriage and loading mechanism
3. Read/write heads
4. Carriage positioning system
5. Photocell assemblies
6. Disk drive electronics assembly

DISK PACK DRIVE SYSTEM.–The purpose of this system is to rotate the disk pack at a nominal speed of 1500 rpm. The disk pack is installed on a disk pack spindle assembly (fig. 4-29). The spindle is driven by a drive motor through a pulley and belt arrangement. The disk speed is monitored by circuits of the MDF controller by using the pulses generated by the sector pulse block photocells (fig. 4-26).

HEAD CARRIAGE.–The head carriage is the assembly that contains the 20 read/write heads. The 102 positions of the heads with respect to the disk surface are defined by the positions of the carriage. Carriage position is monitored by a track photocell assembly and a home pulse photocell assembly (fig. 4-30). The carriage is mounted inside a carriage housing and is supported by roller devices which allow the carriage to be moved in a linear back-and-forth motion. The device that moves the carriage is the hydraulic actuator that is connected to the carriage by a carriage drive rod.

A straight row of gear teeth is machined along one side of the carriage. These gear teeth mesh with and rotate a detent shaft as the carriage is moved. The detent shaft is mounted inside a detent housing (fig. 4-30). A detent gear and a track position disk are attached to the bottom of the shaft. The track position disk (fig. 4-31) is slotted to allow the track pulse

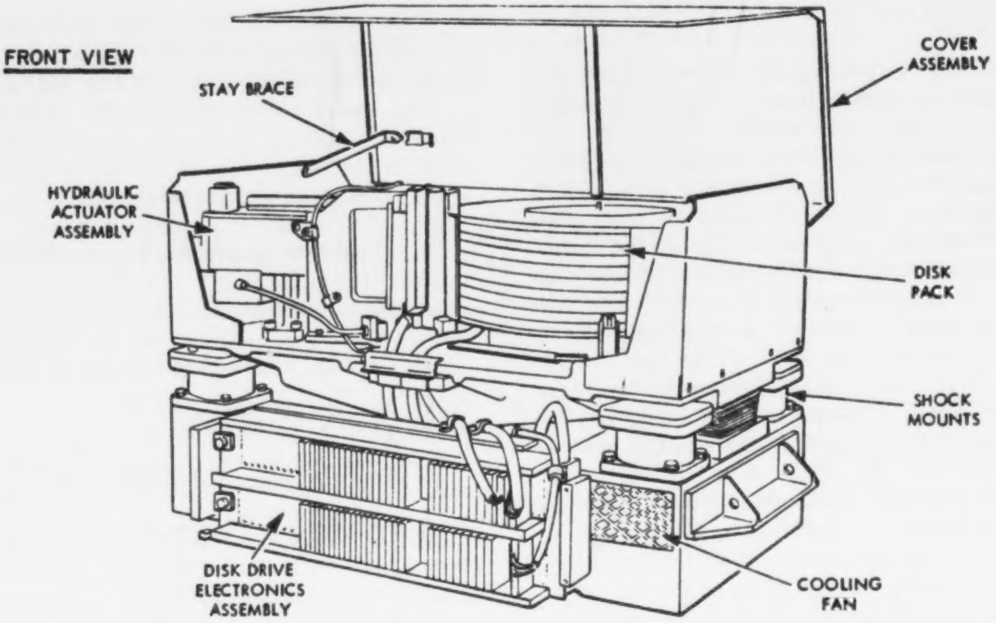


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Figure 4-28.—MDF Disk Drive Assembly.

photocell assembly to sense the position of the disk and hence, the carriage. The slots define the 101 carriage positions used for the read/write operations. The detent gear is engaged by a detent arm for the purpose of locking the detent shaft and carriage from any further movement upon completion of a head-positioning operation. The detent arm is part of a hydraulically operated detent acutator assembly (fig. 4-32).

Another photocell device called the detent pulse block is associated with the detent actuator. This assembly monitors the position of the detent arm to determine whether the arm is in the engaged or disengaged position. During carriage positioning operations, this assembly must indicate that the detent arm is disengaged before the operation is allowed to proceed.

The home position of the carriage is monitored by a separate photocell assembly mounted on the top of the carriage housing. The home position is established when a slotted plate mounted on the carriage allows a light beam to pass and activate the HOME pulse block photocell, fig. 4-30.

There is one more defined position for the carriage that has no corresponding area on the disk surface. This is the retracted stop position which is the physical limit of the carriage movement away from the disk pack. At this position, the heads are clear of the disk surfaces.

HEAD LOADING MECHANISM.—The head loading mechanism is an integral part of the carriage assembly and is installed at the rear of the assembly (fig. 4-33). The mechanism is comprised of a system of links that are interconnected and simultaneously moved by the action of a pushrod attached to the bottom of the assembly. The other end of the pushrod has a device called a head load cam follower

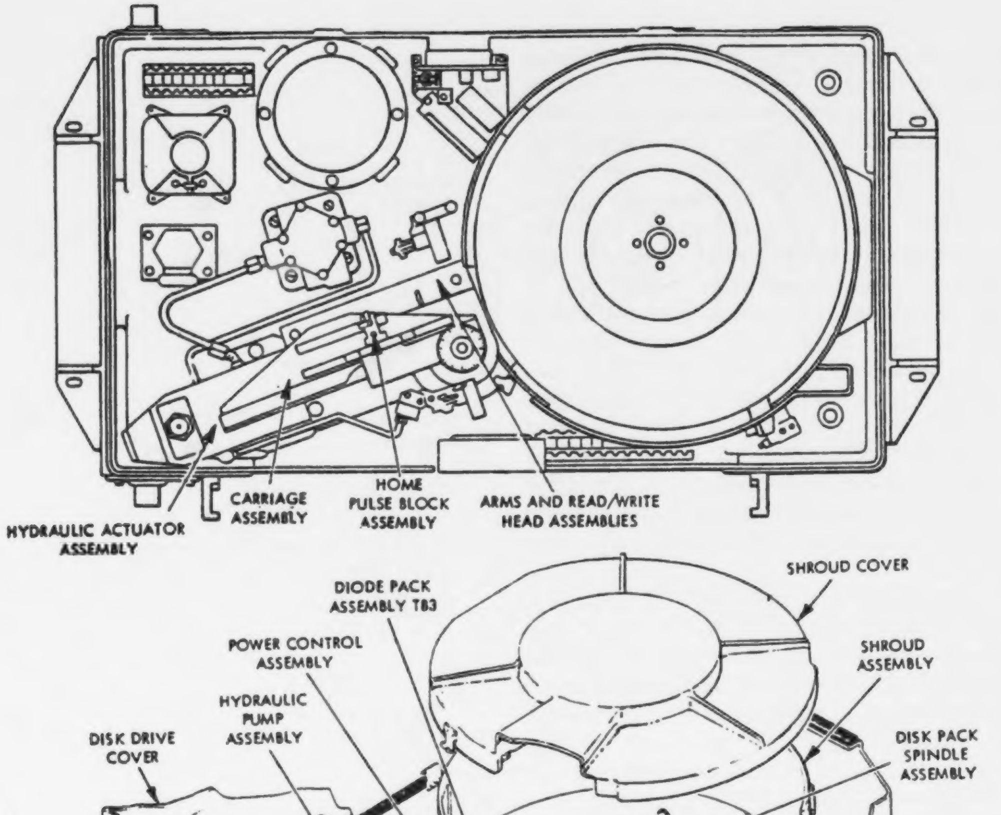
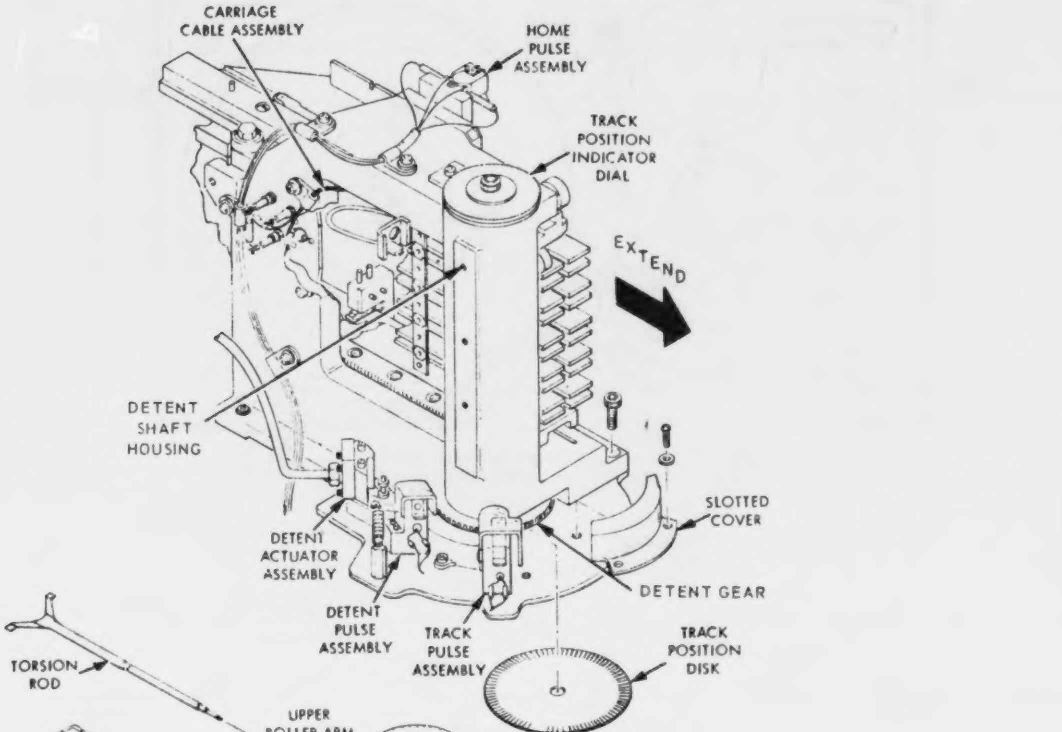
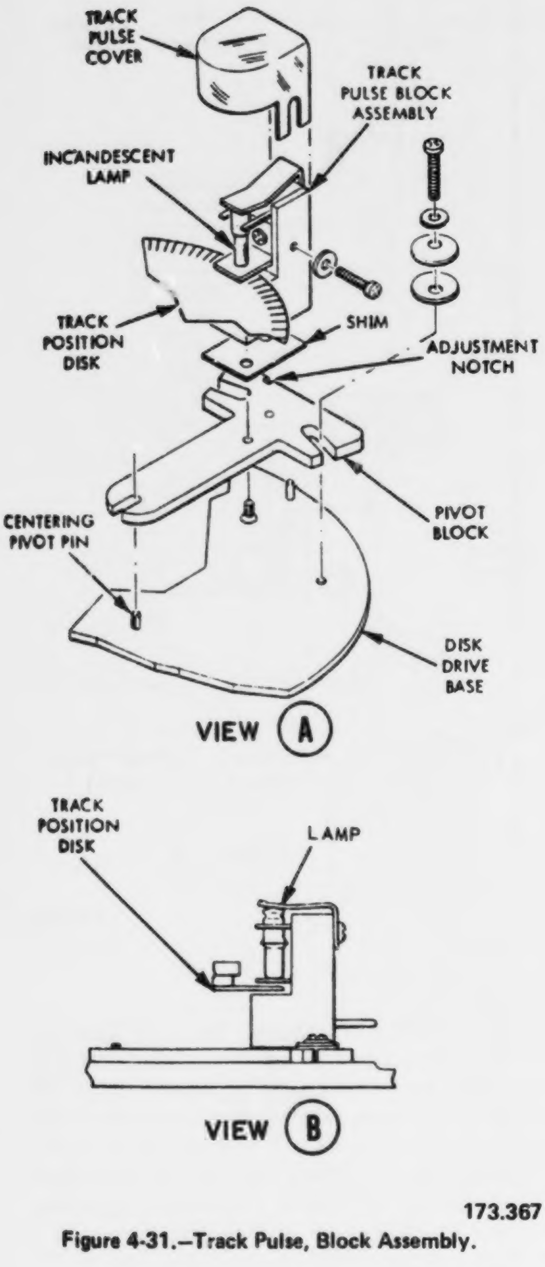

HYDRAULIC ACTUATOR ASSEMBLY
CARRIAGE ASSEMBLY
HOME PULSE BLOCK ASSEMBLY
ARMS AND READ/WRITE HEAD ASSEMBLIES
SHROUD COVER
DIODE PACK ASSEMBLY TB3
POWER CONTROL ASSEMBLY
SHROUD ASSEMBLY
HYDRAULIC PUMP ASSEMBLY
DISK DRIVE COVER
DISK PACK SPINDLE ASSEMBLY
SECTOR PULSE AND SUPPORT ASSEMBLY
EXHAUST AIR FILTER
SHIELD
DRIVE MOTOR
SHIELD
SHROUD AIR FILTER
TERMINAL BOARD TB2
TERMINAL BOARD TB1
DIODE PACK ASSEMBLY TB1
ARMATURE RELAY COVER
TRACK PULSE ASSEMBLY
DETENT PULSE ASSEMBLY
ARMATURE RELAY ASSEMBLY
DETENT ACTUATOR ASSEMBLY
HYDRAULIC ACTUATOR ASSEMBLY
CARRIAGE AND CARRIAGE HOUSING ASSEMBLY

Figure 4-29.—Disk Drive Subassemblies. 173.365


CARRIAGE CABLE ASSEMBLY
HOME PULSE ASSEMBLY
TRACK POSITION INDICATOR DIAL
EXTEND
DETENT SHAFT HOUSING
SLOTTED COVER
DETENT ACTUATOR ASSEMBLY
DETENT GEAR
DETENT PULSE ASSEMBLY
TRACK PULSE ASSEMBLY
TRACK POSITION DISK
TORSION ROD
UPPER ROLLER ARM ASSEMBLY
HEAD/ARM ASSEMBLY
HOME PULSE SLOT
EXTEND
HEAD/ARM CLAMP
LOWER ROLLER ARM ASSEMBLY
HOME PULSE BLOCK ASSEMBLY
CARRIAGE
CARRIAGE ASSEMBLY
MAGNET ASSEMBLY
HEAD LOAD LATCH ASSEMBLY
HEADS EXTENDED (SENSITIVE) SWITCH
ACTUATOR SPRING
CARRIAGE HOUSING
HEAD LOADING CAM ASSEMBLY
INCANDESCENT LAMP
MOUNTING BRACKET

173.366

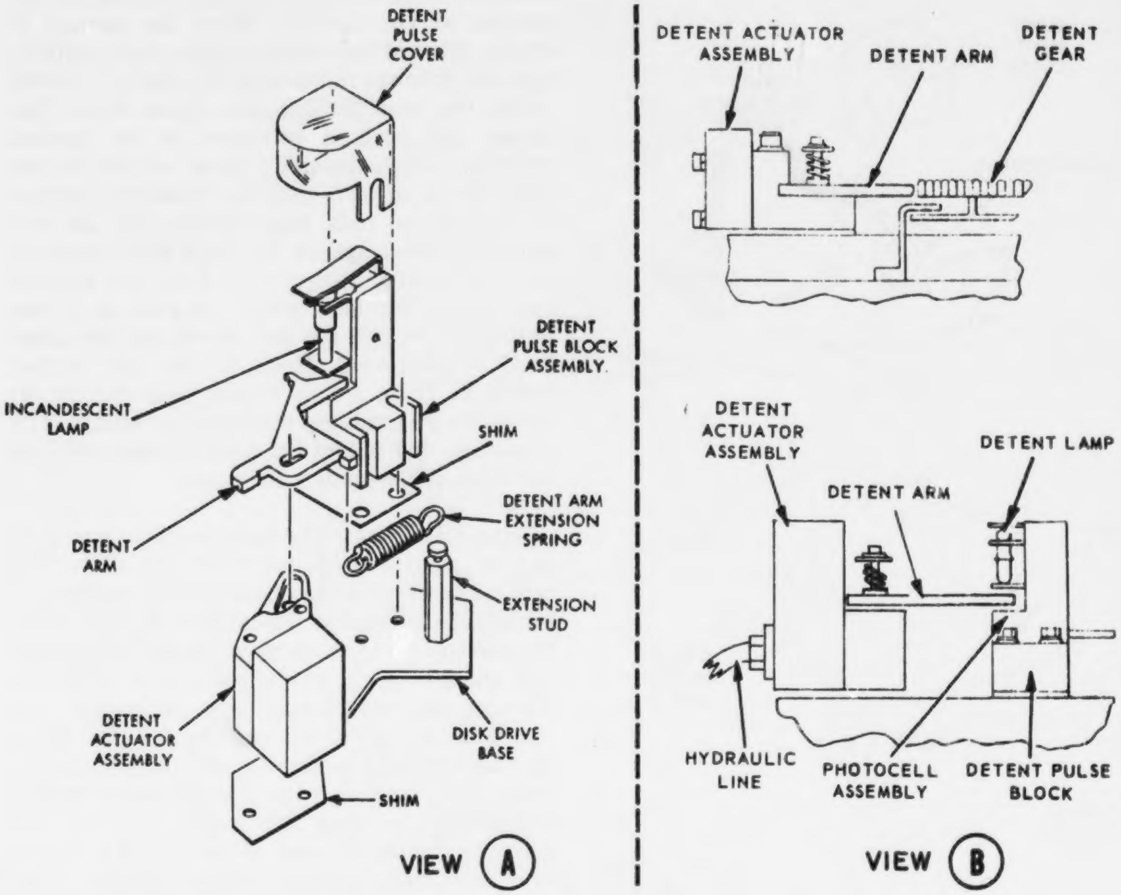
Figure 4-30.—Carriage and Carriage Housing Assemblies.



173.367
Figure 4-31.—Track Pulse, Block Assembly.

attached. This follower is dragged along by the motion of the carriage. When the carriage is moved forward from the retracted stop position, the cam follower rides along the edge of a device called the head loading cam, figure 4-33. This causes the pushrod to move in an upward direction which imparts a linear motion to the links which, in turn, imparts a rotational motion to the torsion rods. Each torsion rod has two arms that bear against the read/write heads as the rod rotates, figure 4-34. Each rod services two heads; one head will be moved up to the bottom surface of the disk above, and the other head is positioned down to the disk surface below it. There are 10 torsion rods for the 20 heads; all 20 heads are positioned in unison. The operation that moves the heads toward the disk surface is called loading the heads.

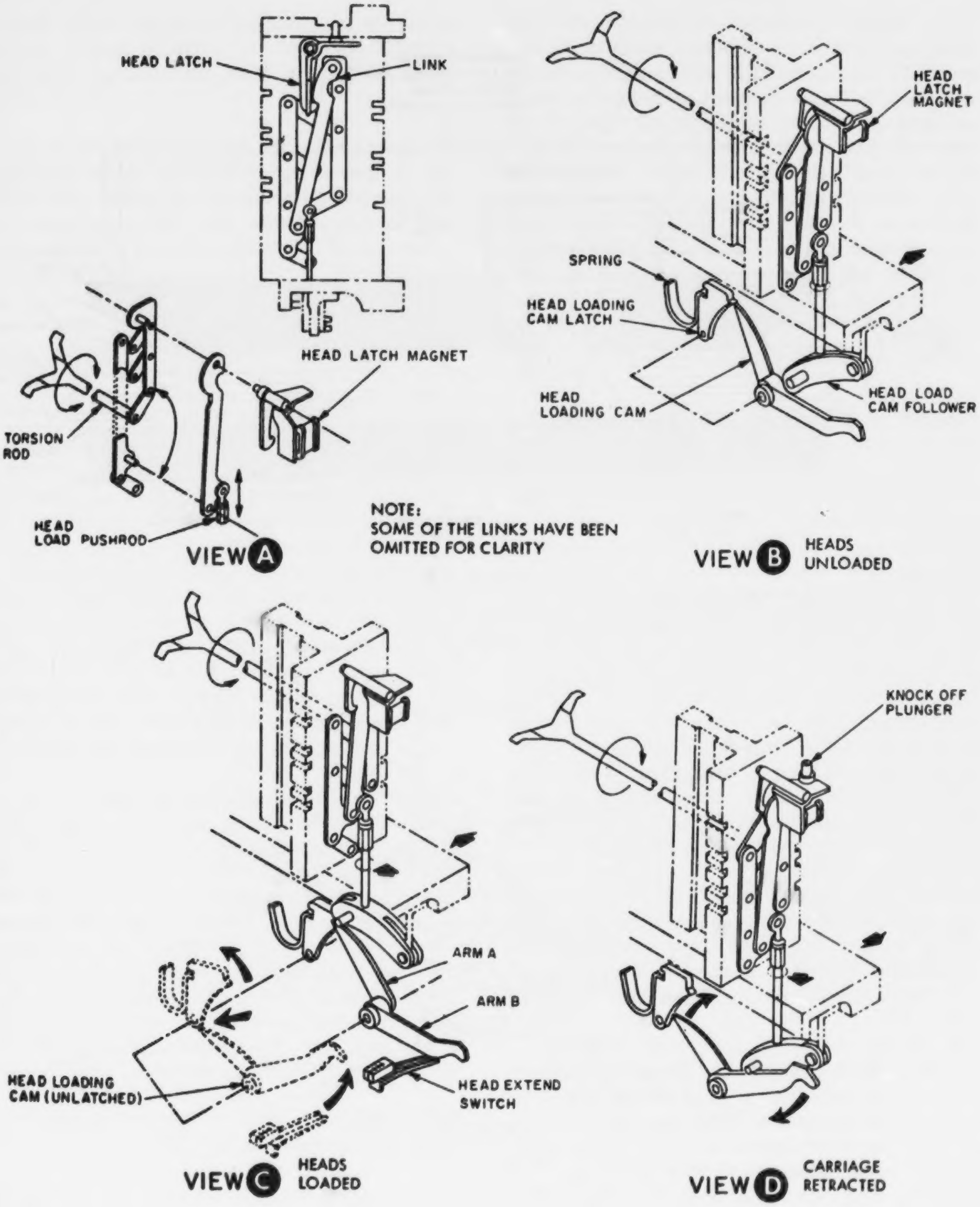
Head Loading.—The head loading procedure is a separate and unique MDF operation. The carriage must be in the retracted stop position to initiate the operation. To execute the operation, the carriage is forced to move almost completely into the disk pack. This is required in order for the cam follower to ride along the loading cam arm A all the way to the end (fig. 4-33,C). When the cam follower reaches the end of the cam, the links and torsion rods should have moved sufficiently to load the heads. As the cam follower reaches the end of the cam, it knocks a cam latch away from its support arm A of the loading cam. This causes the cam to pivot, lifting cam arm B off of the head extend switch actuator. The result is that a signal is routed through the switch to notify the control circuitry in the MDF controller that the heads are loaded. The signal is called HEADS EXTENDED. The links, and the heads, are maintained in the heads loaded position by a head latch and magnet, figure 4-33,A. The head latch has a pointed tip that drops into a notch in one of the links. A magnet is energized to hold the latch in the notch. Once the HEADS EXTENDED signal is generated, the carriage is moved in a reverse direction to the HOME position, then moved forward to cylinder 00. This is where the head loading operation is terminated. However, the head loading cam has been left in a configuration that does not provide the proper effect for another head


DETENT PULSE COVER
DETENT PULSE BLOCK ASSEMBLY
INCANDESCENT LAMP
SHIM
DETENT ARM
DETENT ARM EXTENSION SPRING
EXTENSION STUD
DETENT ACTUATOR ASSEMBLY
DISK DRIVE BASE
SHIM
VIEW A
DETENT ACTUATOR ASSEMBLY
DETENT ARM
DETENT GEAR
DETENT ACTUATOR ASSEMBLY
DETENT LAMP
DETENT ARM
HYDRAULIC LINE
PHOTOCELL ASSEMBLY
DETENT PULSE BLOCK
VIEW B

173.368

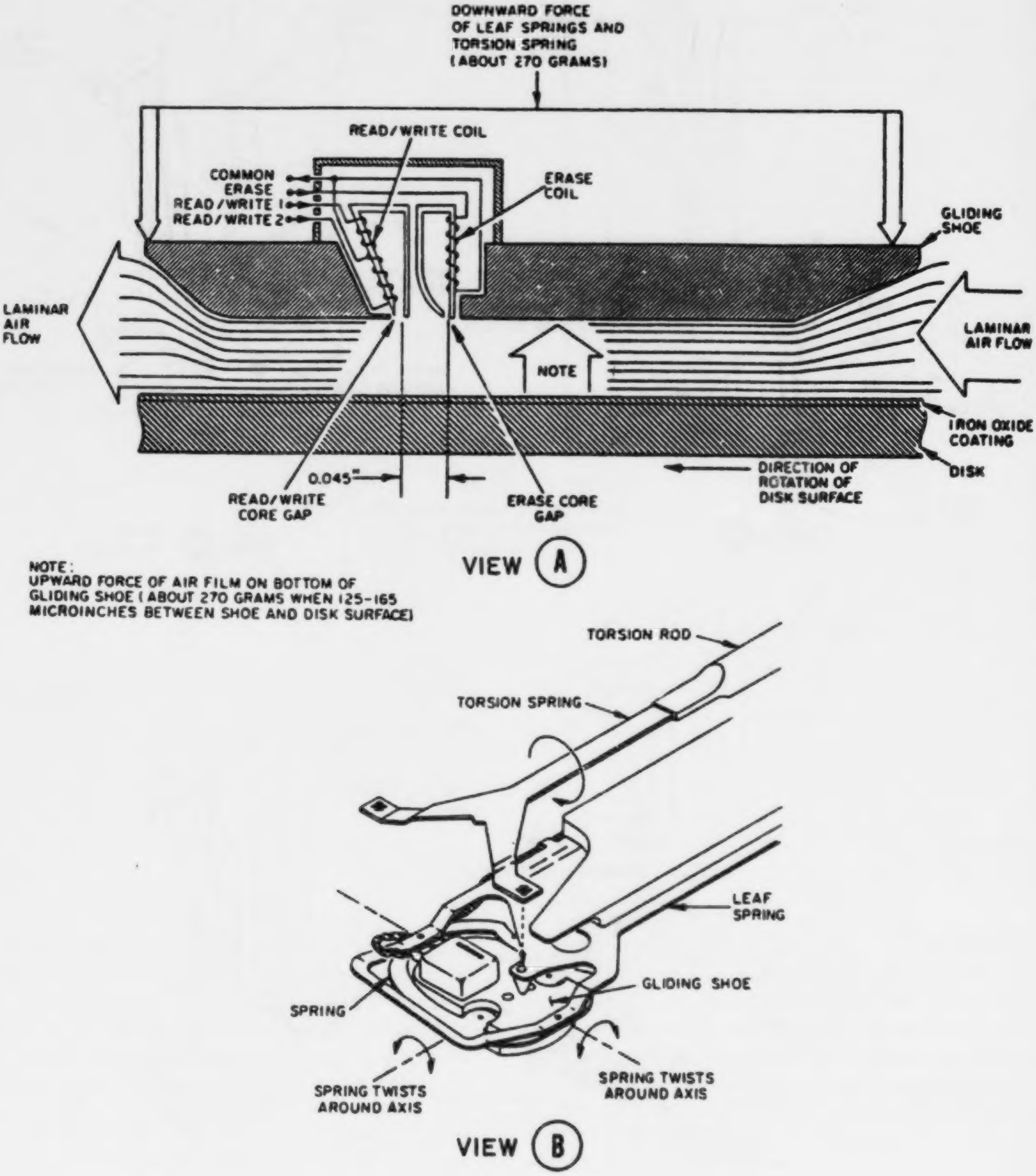
Figure 4-32.—Detent Assemblies.

loading operation. Repositioning the head loading cam is accomplished during a return to the retracted stop position. The head loading operation is always started with the carriage in the retracted stop position, which is also the position the carriage is in when the MDF is turned off. When the MDF is secured, the carriage is forced to move to its retracted stop position. The reverse movement of the carriage between the home and retracted stop position causes the cam follower to contact the cam arm B (fig. 4-33,C). As the carriage continues in the reverse direction, the cam pivots, allowing the spring loaded cam latch to return to its latch position. This reestablishes the configuration that is required for another head loading operation. Any situation that would cause the carriage to retract should also cause the head latch magnet to deenergize and release the links. If the links fail to unlatch, the reverse movement of the carriage will cause a knock off plunger, attached to the top of the carriage, to strike a pin that protrudes down from the top of the carriage housing. This, in turn, forces the plunger to knock the head latch free, releasing the links and unloading the heads, figure 4-33, view D. The movement of the carriage torwards the retracted stop also causes arm B of the


HEAD LATCH
LINK
HEAD LATCH MAGNET
TORSION ROD
HEAD LOAD PUSHROD
VIEW A
HEAD LATCH MAGNET
SPRING
HEAD LOADING CAM LATCH
HEAD LOADING CAM
HEAD LOAD CAM FOLLOWER
VIEW B
HEADS UNLOADED
ARM A
ARM B
HEAD LOADING CAM (UNLATCHED)
HEAD EXTEND SWITCH
VIEW C
HEADS LOADED
KNOCK OFF PLUNGER
VIEW D
CARRIAGE RETRACTED

NOTE:
SOME OF THE LINKS HAVE BEEN OMITTED FOR CLARITY

Figure 4-33.—Head Load Mechanism. 173.369


DOWNWARD FORCE OF LEAF SPRINGS AND TORSION SPRING (ABOUT 270 GRAMS)
READ/WRITE COIL
COMMON
ERASE
READ/WRITE 1
READ/WRITE 2
ERASE COIL
GLIDING SHOE
LAMINAR AIR FLOW
LAMINAR AIR FLOW
NOTE
IRON OXIDE COATING
DISK
0.045"
DIRECTION OF ROTATION OF DISK SURFACE
READ/WRITE CORE GAP
ERASE CORE GAP
VIEW (A)
NOTE:
UPWARD FORCE OF AIR FILM ON BOTTOM OF GLIDING SHOE (ABOUT 270 GRAMS WHEN 125-165 MICROINCHES BETWEEN SHOE AND DISK SURFACE)
TORSION ROD
TORSION SPRING
LEAF SPRING
GLIDING SHOE
SPRING
SPRING TWISTS AROUND AXIS
SPRING TWISTS AROUND AXIS
VIEW (B)

173.370

Figure 4-34.—Read/Write Head.

loading cam to contact the actuator of the heads extend switch, thereby removing the HEADS EXTEND signal to the MDF controller, figure 4-33, view C.

READ/WRITE HEADS.–There are twenty read/write heads installed in the carriage of the DDU. The heads are mounted on the ends of arm assemblies that are constructed in leaf spring design (fig. 4-30). When the torsion rod is rotated, the head arm assembly is bent towards the disk surface. The heads must be prevented from contacting the disk surface. This is accomplished by means of a flow of air that is directed across the surface of each of the disks. Forced air is generated by a blower mounted in the bottom of the DDU. The air is directed into the hollow hub of the disk pack and out of air holes which direct the air across the disk surfaces. (See fig. 4-25.) This feature, along with the requirement that the disks must be rotating at 72% of rated speed, will cause a cushion of air to lift the heads away from the surface. The heads will be suspended between the air cushion and the pressure of the torsion rods (fig. 4-34). If the rotational speed of the disk pack were to fall below 72% of the required normal value (1500 rpm), the carriage would be forced to retract at high speed to prevent the heads from scratching and destroying the disk surface.

The heads contain an erase coil and a read/write coil. The erase coil is used in conjunction with a write operation to remove any previous recorded data. The read/write coil uses one half of the winding to write logic 1s and the other half to write logic 0s. During read operations, the entire winding is used. During write operations, only one head at a time will have current applied to it. The head selection logic, contained in the MDF controller, provides control signals that enable only the head that is required for a particular operation.

CARRIAGE POSITIONING SYSTEM.–This system is comprised of a hydraulic pump and a hydraulic actuator assembly, figure 4-29. The detent actuator is considered part of this system. The purpose of this system is to position the carriage. This is accomplished by means of a drive rod that is connected between the carriage and the hydraulic actuator, figure 4-35. Operation of the hydraulic actuator is controlled by access logic in the MDF controller. The term access is applied to the operation that positions the carriage. The hydraulic actuator housing has two sections; the cylinder block and the valve block, figure 4-36. The cylinder block houses four solenoids and a hydraulic cylinder. The valve block contains the hydraulic valves that channel the oil to the hydraulic cylinder and the detent actuator. The direction of the oil flow is controlled by the valves through the operation of the solenoids. The solenoids respond to control signals from the access logic of the MDF controller.

Hydraulic Cylinder.–The hydraulic cylinder houses two separate pistons; the drive rod and the extend piston. The extend piston pushes the drive rod from the retracted stop position to the home position. Figure 4-36 illustrates the extend piston at the forward limit of its travel. To move the drive rod from the home position to a cylinder position requires operation of the FORWARD and SLOW solenoids to channel the flow of oil against the back side of the drive rod. The extend piston is hollow to allow oil to flow through it to the back side of the drive rod, figure 4-36. To move the rod forward, the forward solenoid is energized which allows oil to enter the forward valve at port M2, figure 4-36. The oil is then routed over to the slow valve, into the cylinder, and through the extend piston to the back side of the drive rod. To cause the rod to move in reverse, the forward solenoid is deenergized. This causes the forward valve to route the oil to the front side of the drive rod piston. At the same time, the pressure at the back side of the piston is vented off through the slow valve and port S5 of the forward valve.

If MDF power is removed, all of the solenoids become deenergized. The pressure remaining in the lines is sufficient to move the drive rod and the extend piston to the retracted stop position. The oil pressure, that was keeping the extend piston at its maximum forward limit, will be vented off through the path provided when the extend solenoid deenergized. Prior to any operation of the drive rod, the detent solenoid must be operated. This causes the

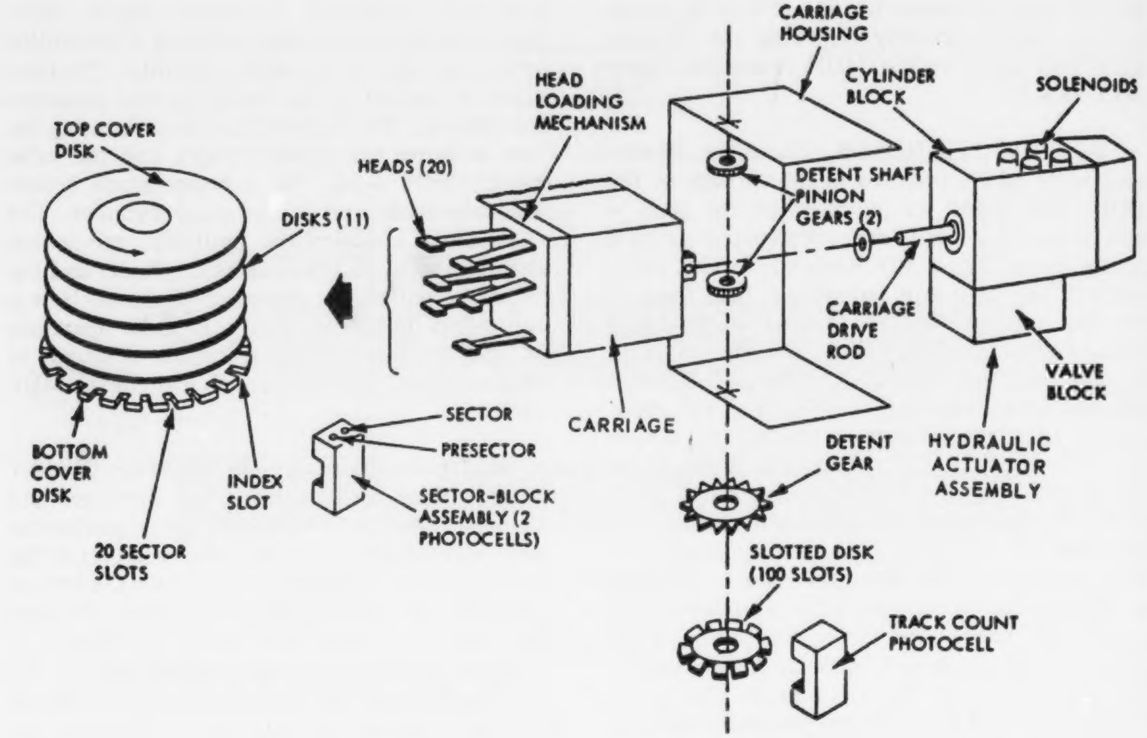

CARRIAGE HOUSING
HEAD LOADING MECHANISM
CYLINDER BLOCK
SOLENOIDS
TOP COVER DISK
HEADS (20)
DISKS (11)
DETENT SHAFT PINION GEARS (2)
CARRIAGE DRIVE ROD
VALVE BLOCK
SECTOR
PRESECTOR
CARRIAGE
BOTTOM COVER DISK
INDEX SLOT
SECTOR-BLOCK ASSEMBLY (2 PHOTOCELLS)
DETENT GEAR
HYDRAULIC ACTUATOR ASSEMBLY
20 SECTOR SLOTS
SLOTTED DISK (100 SLOTS)
TRACK COUNT PHOTOCELL

Figure 4-35.—Carriage Positioning, Functional Diagram. 173.371

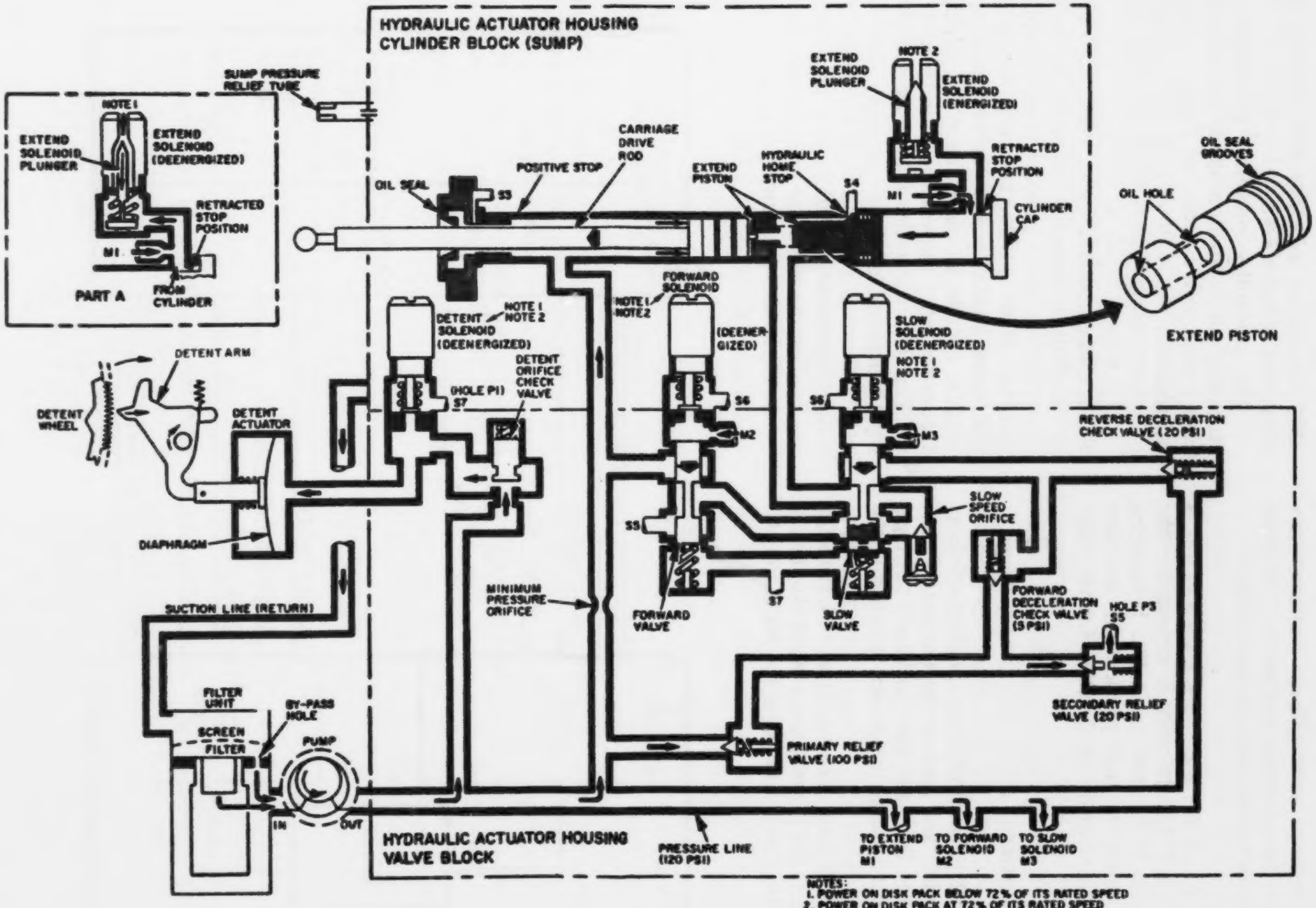
detent actuator to disengage the detent arm and allows the carriage to become unlocked in preparation for a required positioning operation. The detent solenoid remains energized throughout an access operation, at the end of which, the solenoid will be deenergized to allow the carriage to become detented at its ordered position.

Energizing the forward solenoid allows oil pressure to be applied to the drive rod through the forward valve and the slow valve. The SLOW solenoid becomes energized when the carriage is within 10 cylinders of the commanded position. During forward access operations, energizing the slow solenoid causes the oil coming from the forward valve to pass through a slow-speed orifice in the slow valve before it is applied to the drive rod. The orifice reduces the oil flow to the back side of the drive rod. During reverse accessing, the slow solenoid is energized to restrict the flow of oil returning from the back side of the drive rod piston and to create a back pressure which reduces the speed of the reverse travel of the drive rod. The slow feature is designed into the system to prevent overshoot of the carriage and to allow time for the detent mechanism to lock the carriage into its ordered position.

During the forward access operations, the slow solenoid is deenergized after detent, but the forward solenoid remains energized to hold the carriage tight against the detent mechanism. For reverse operations, the forward solenoid is reenergized after detent.

PHOTOCELL ASSEMBLIES.—There are four photocell assemblies installed in the DDU:

1. Home pulse block
2. Track pulse block
3. Detent pulse block
4. Sector pulse block


HYDRAULIC ACTUATOR HOUSING CYLINDER BLOCK (SUMP)
SUMP PRESSURE RELIEF TUBE
NOTE 1
EXTEND SOLENOID PLUNGER
EXTEND SOLENOID (DEENERGIZED)
RETRACTED STOP POSITION
M1
PART A
FROM CYLINDER
NOTE 2
EXTEND SOLENOID PLUNGER
EXTEND SOLENOID (ENERGIZED)
RETRACTED STOP POSITION
M1
CYLINDER CAP
CARRIAGE DRIVE ROD
OIL SEAL
S3
POSITIVE STOP
EXTEND PISTON
HYDRAULIC HOME STOP
S4
OIL SEAL GROOVES
OIL HOLE
EXTEND PISTON
DETENT SOLENOID (DEENERGIZED)
NOTE 1 NOTE 2
(HOLE P1) S7
DETENT ORIFICE CHECK VALVE
DETENT ARM
DETENT WHEEL
DETENT ACTUATOR
DIAPHRAGM
FORWARD SOLENOID
NOTE 1 NOTE 2
(DEENERGIZED)
S6
M2
S5
FORWARD VALVE
S7
SLOW SOLENOID (DEENERGIZED)
NOTE 1 NOTE 2
S6
M3
SLOW SPEED ORIFICE
SLOW VALVE
REVERSE DECELERATION CHECK VALVE (20 PSI)
FORWARD DECELERATION CHECK VALVE (5 PSI)
HOLE P3 S5
SECONDARY RELIEF VALVE (20 PSI)
PRIMARY RELIEF VALVE (100 PSI)
MINIMUM PRESSURE ORIFICE
SUCTION LINE (RETURN)
FILTER UNIT
BY-PASS HOLE
SCREEN FILTER
PUMP
IN
OUT
HYDRAULIC ACTUATOR HOUSING VALVE BLOCK
PRESSURE LINE (120 PSI)
TO EXTEND PISTON M1
TO FORWARD SOLENOID M2
TO SLOW SOLENOID M3

NOTES:
1. POWER ON DISK PACK BELOW 72% OF ITS RATED SPEED
2. POWER ON DISK PACK AT 72% OF ITS RATED SPEED
3. HYDRAULIC PRESSURE ⟶

173.372

Figure 4-36.—Hydraulic Actuator.

The sector pulse block contains two photocells; the pre-sector and sector. All of the assemblies have been discussed previously.

DISK DRIVE ELECTRONICS ASSEMBLY.–This assembly is mounted to the side of the DDU (see fig. 4-28). It contains TYPE 3 modules that provide the interface between the elements of the DDU and the MDF controller.

MDF Controller

The MDF controller is comprised of those logic circuits that control the transfer of data between the DCC and disk pack, and the logic circuits that control the devices installed in the DDU.

The MDF controller interfaces with the DCC by means of DCC input and output channels 7 and 8. Data transfer between the MDF and the DCC requires an exchange of control signals as illustrated in figure 4-37.

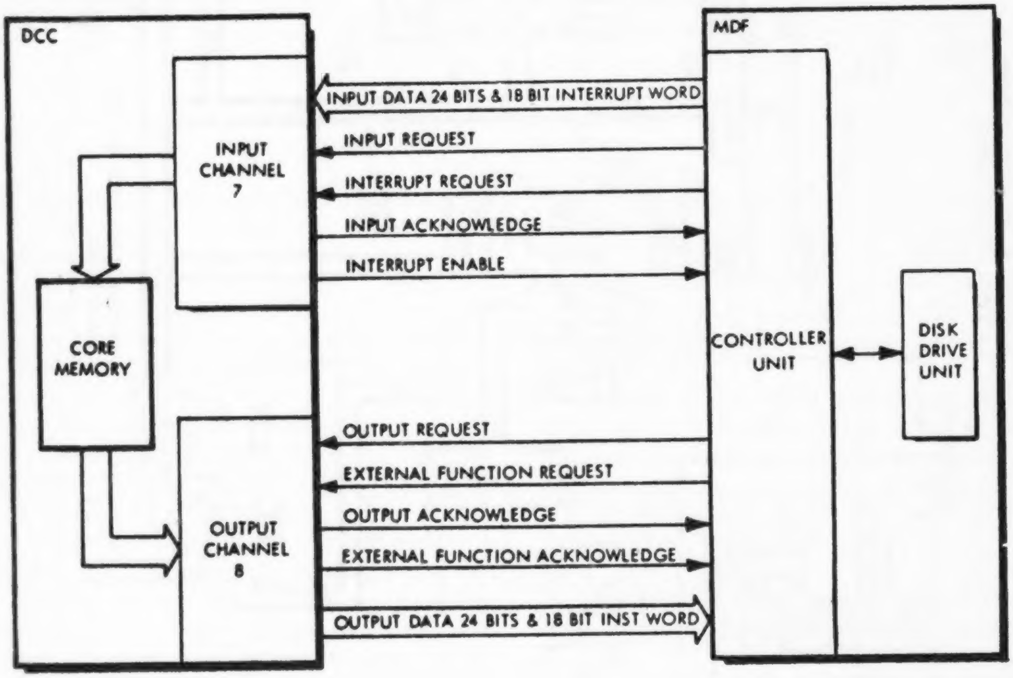
The controller operation is initiated by receipt of an instruction word. The instruction class will define one of three types of operations:

1. Access
2. Data transfer
3. Write address

The MDF instruction will cause only designated logic circuits to become enabled; the specific circuits are determined by the signals that evolve when the instruction is decoded.

The MDF controller circuits are divided into eight functional blocks:

1. Operation control logic
2. Data transfer logic
3. Cylinder access logic


DCC
MDF
INPUT CHANNEL 7
INPUT DATA 24 BITS & 18 BIT INTERRUPT WORD
INPUT REQUEST
INTERRUPT REQUEST
INPUT ACKNOWLEDGE
INTERRUPT ENABLE
CORE MEMORY
CONTROLLER UNIT
DISK DRIVE UNIT
OUTPUT REQUEST
EXTERNAL FUNCTION REQUEST
OUTPUT ACKNOWLEDGE
EXTERNAL FUNCTION ACKNOWLEDGE
OUTPUT CHANNEL 8
OUTPUT DATA 24 BITS & 18 BIT INST WORD

173.373

Figure 4-37.–MDF-DCC Interface.

4. Head select logic
5. Sector select logic
6. Read/Write control logic
7. Read/Write logic
8. Protective logic

Figure 4-38, a foldout at the end of this chapter, pertains to the following discussion.

OPERATION CONTROL LOGIC.–The purpose of this logic block is to generate enabling signals and timing terms and distribute them to the remainder of the MDF controller logic, figure 4-38. Some of the circuits that comprise this logic block are as follows:

EF Controller.–This circuit transmits an EF REQUEST signal to the DCC and receives the EF ACKNOWLEDGE signal from the DCC. The request signal notifies the DCC that the MDF is available to receive an instruction, and the acknowledge signal from the DCC notifies the MDF that the DCC is ready to transmit an instruction.

Operation Register and Decode Logic.–This circuitry receives the OP CODE portion of the instruction word, figure 4-39. The OP CODE forms bits 0 through 5 of the instruction and defines not only the class of instruction but also the mode of execution, when applicable. From these bits the decode logic manufactures enabling signals that prepare those circuits that are required to execute the particular instruction.

1.46 MHz Clock Oscillator.–This circuit is the source of MDF timing. The outputs are selectively utilized to provide either 1.46 MHz clock pulses or halved to provide 730 kHz clock pulses.

Bit/Byte Sequencer.–This circuit generates 25 timing terms that are used to sequentially step the MDF logic through an operation. All 25 timing terms are not always required. In some cases only six timing pulses are required to regulate the steps in an MDF routine. The circuit is comprised of six flip-flops that make up a bit counter, four flip-flops that comprise a byte counter, and an additional flip-flop whose set state is referred to as bit 25, figure 4-40. The entire group of flip-flops comprises a ring counter. The outputs from each individual bit counter flip-flop is called a sequence, and the output from one of the byte flip-flops is simply referred to as a byte. When reset, the sequencer configuration will have the first stage of the bit sequencer and the first stage of the byte sequencer both set. This establishes an MDF time of BYTE 1/Sequence 1. The sequencer can be stepped by either 1.46 MHz clock or 730 kHz clock. The sequencer starts from a BYTE 1/SEQ 1 condition, and the application of 5 more step pulses will cause the bit counter stages to sequentially set until SEQ 6 is set. The first step pulse that occurs after stage 6 of the bit counter sets will cause stage 2 of the byte counter to set and stage 1 of the bit counter to also set, and the remaining stages of the bit counter to be reset. This configuration would be defined as BYTE 2/SEQ 1. As stepping pulses continue to step the sequencer, a configuration is finally achieved where the last stages of both counters become set (BYTE 4/SEQ 6). At this time, the occurrence of another step pulse would cause all flip-flops of both counters to reset and the BIT 25 flip-flop to set. This configuration establishes MDF time (bit 25). As each of the counter flip-flops set, their set outputs are fed to other MDF circuits to sequentially enable the execution of each step of an instruction. The 25 unique states of the BIT/BYTE sequencer are also used to establish the allotted area on the disk surface that will be assigned to the 25-bit data words. The surface area that passes under the read/write heads during the time period between each sequence state defines the limits of recording space allotted to each bit.

DATA TRANSFER LOGIC.–The purpose of the DATA TRANSFER LOGIC is to gate 24-bit words to and from the DCC. As a requirement for transfer operations, the DCC and MDF must exchange control signals as illustrated in figure 4-38. The transfer logic handles data, interrupt, and instruction words. Data to and from the DCC is in a parallel format. Data to and from the disk pack is transferred one bit at a time, or in serial form. The data transfer logic contains an I/O register that receives the parallel data. A SERIAL DATA

ACCESS CLASS

17–14	13–7	6–5	4–0
SPARE	CYLINDER ADDRESS	SPARE	OP CODE

Instruction	OP Code
Status request	10000
Direct seek	00001
Master clear	00010

WRITE ADDRESS CLASS

17	16	15–14	13–7	6–5	4–0
WRT PROT	MODE SEL	SPARE	CYLINDER ADDRESS	SPARE	10011

DATA TRANSFER CLASS

17–13	12	11–7	6–5	4–0
SECTOR ADDRESS	NEXT SECT	HEAD ADR	SPARE	OP CODE

Instruction	OP Code
Write track	00100
Write sector	10101
Write track cylinder	10110
Write sector cylinder	00111
Read track	01000
Read sector	11001
Read track cylinder	11010
Read sector cylinder	01011
Track compare	11100
Sector compare	01101
Track cylinder compare	01110
Sector cylinder compare	11111

173.375

Figure 4-39.—MDF Instruction Word Formats.

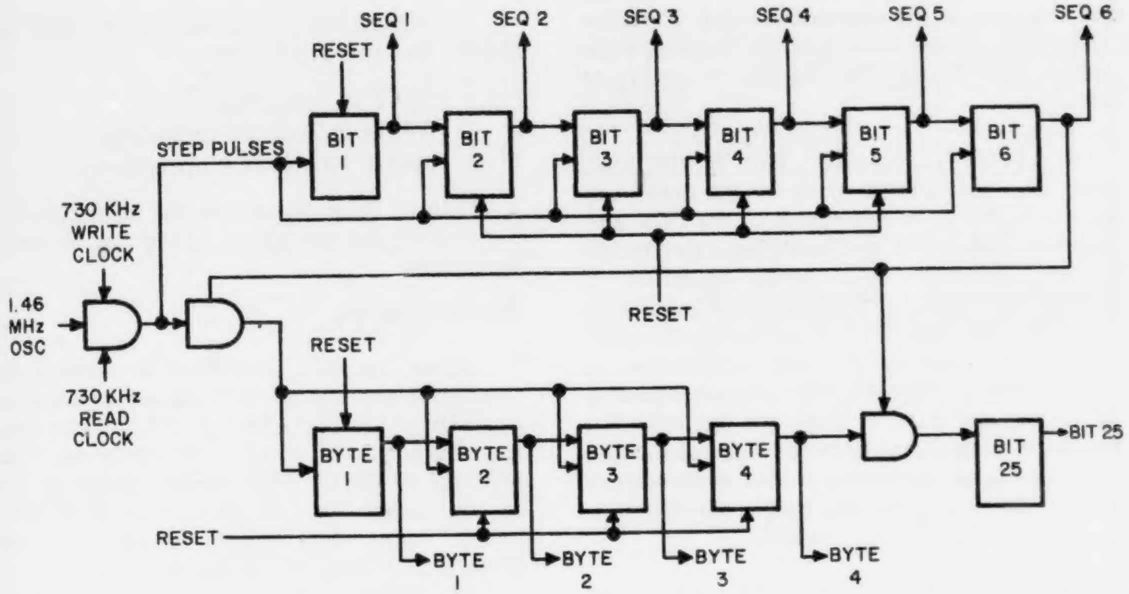
REGISTER (SDR) is also provided to transfer or receive the serial data to and from the disk pack. The I/O register and the SDR register exchange the 24-bit data words in parallel format. With the exception of instruction words, data coming from the DCC is first placed in the I/O register and then transferred to the SDR. From the SDR, the data is serially gated, by means of sequencer timing terms, to the disk pack. When data is read from the disk pack, it is first gated serially into the SDR, and then it is transferred in parallel as a 24-bit word into the I/O register; from there it is gated by the DCC into the DCC I/O section.

Instruction words from the DCC are also placed into the I/O register but transferred to the SDR. Instead, the OP CODE bits are sent to the operation register in the operation control logic, and the other bits of the instruction are sent to appropriate cylinder, head, and sector address circuits.

CYLINDER ACCESS LOGIC.—The purpose of this logic block is to control the sequence of operation of the solenoids in the hydraulic actuator of the DDU. The signals sent to the solenoids are developed in the cylinder access control logic by comparing the current carriage position with an ordered carriage position.

The access logic is enabled as a result of an access type instruction. This instruction is used to position the carriage prior to each read or write operation. The instruction, which is placed in the I/O register, will contain a CYLINDER ADDRESS which is transferred to a circuit called the cylinder counter. The cylinder counter is disabled when the carriage is in the HOME position or moving to HOME position for a MASTER CLEAR, and receives pulses from the TRACK PULSE BLOCK assembly as the carriage is accessed. For DIRECT SEEK operation, the initial contents of the counter are fed from the difference generator. When the counter contents are counted to zero, the access logic sends a signal to the detent solenoid which causes the carriage to be locked at the present position. This position should be that of a cylinder whose number designation corresponds to the original contents of the cylinder counter. This is only a broad explanation of an access operation. There are two types of access operations and their method of execution differs slightly. A more detailed explanation of these operations will be covered later in this chapter.

HEAD SELECT LOGIC.—The purpose of the HEAD SELECT LOGIC is to enable a designated read/write head during a read/write operation. The designation of a particular head is, in effect, also specifying which disk surface will be used for the operation. A head is selected by transferring the HEAD ADDRESS bits of a data transfer class instruction into the head counter circuit of the head select logic. A head address decode circuit decodes the bits in the counter and generates enabling signals that are sent to the DDU to enable either a read amplifier or a write current generator. The



173.376

Figure 4-40.–BIT/BYTE Sequencer.

decoded head address information is also sent to the read/write control logic for the address compare cycle of data transfer instructions.

SECTOR SELECT LOGIC.–This logic block receives the sector address bits of an instruction word. The SECTOR ADDRESS bits are placed in the sector register circuit of the sector select logic. The contents of the sector register are transferred to the read/write logic, for address comparison, and are also sent to the sector compare circuit within the sector select logic.

The sector pulses from the sector photocell assemblies are sent to the sector counter within the same sector logic block. The counter stores the count which defines the numerical designation of the sector passing beneath the heads. The sector compare logic compares the counter contents with the sector register contents. When the values compared are equal, the sector compare logic circuit enables the read/write logic to read or write on the disk surface area that is passing under the heads at that instant. This circuitry is only required if the sector mode has been designated for the read or write operation.

READ/WRITE CONTROL LOGIC.–One of the primary functions of this logic block is to generate the enabling signals at the proper time to initiate the reading or writing of data.

The data transfer instruction, figure 4-39, always contains an address which specifies the location on the disk pack where the data is to be placed or retrieved. The data locations on the disk are defined by the addresses written when the disk was formatted.

After the instruction is decoded, the address compare routine is initiated by enabling signals from the read/write control logic for both a read and a write operation. This routine causes addresses to be read from the disk pack and assembled in the SDR. The contents of the SDR and the address bits now located in the head, sector, and cylinder select logic are all compared in the address compare circuit. The addresses are continuously read and compared until an address from the disk pack matches the address that was part of the instruction word. When the valid address comparison is made, the read/write control logic enables the reading or writing of data.

READ/WRITE LOGIC.–This is the logic block that provides the path for the data from the read/write head electronics to the SDR and from the SDR to the read/write head electronics in the DDU. During a write operation, a CLOCK/DATA SERIALIZER circuit combines the clocks and data as they are sent to the head electronics. During a read operation, a CLOCK/DATA SEPARATION circuit separates the clocks and data as they are fed into the read/write logic from the head electronics in the DDU. The head electronics are the write current drivers and read amplifiers that are installed in the disk drive electronics assembly.

PROTECTIVE LOGIC.–This block of circuits monitors for alarm conditions within the MDF controller and DDU.

When an operation is terminated before it has been completely executed or after it has been executed, the protective logic will record the reason for termination in an interrupt register and send an interrupt signal to the DCC. The DCC will respond by returning an interrupt enable signal to the MDF protective logic. This will enable the protective logic to transfer the contents of the interrupt register to the I/O register in the data transfer logic. The DCC will then transfer the contents of the I/O register, as a 24-bit interrupt word, from the MDF and decode it to determine the cause of termination of the operation.

The protective logic also monitors the sector pulses to determine if the disk pack is rotating at the proper speed. If the disk pack speed becomes less than 72% of 1500 rpm during an operation, the DISK SPEED MONITOR circuit will cause circuits of the access control logic to become disqualified. As a result, the heads will be unloaded, and the carriage will be forced to move, in fast reverse, to the retracted stop position, thus pulling the heads clear of the disk pack.

MDF OPERATIONS

The operations performed by the MDF are divided into three categories:

1. ACCESS operations
2. WRITE ADDRESS operations
3. DATA TRANSFER operations

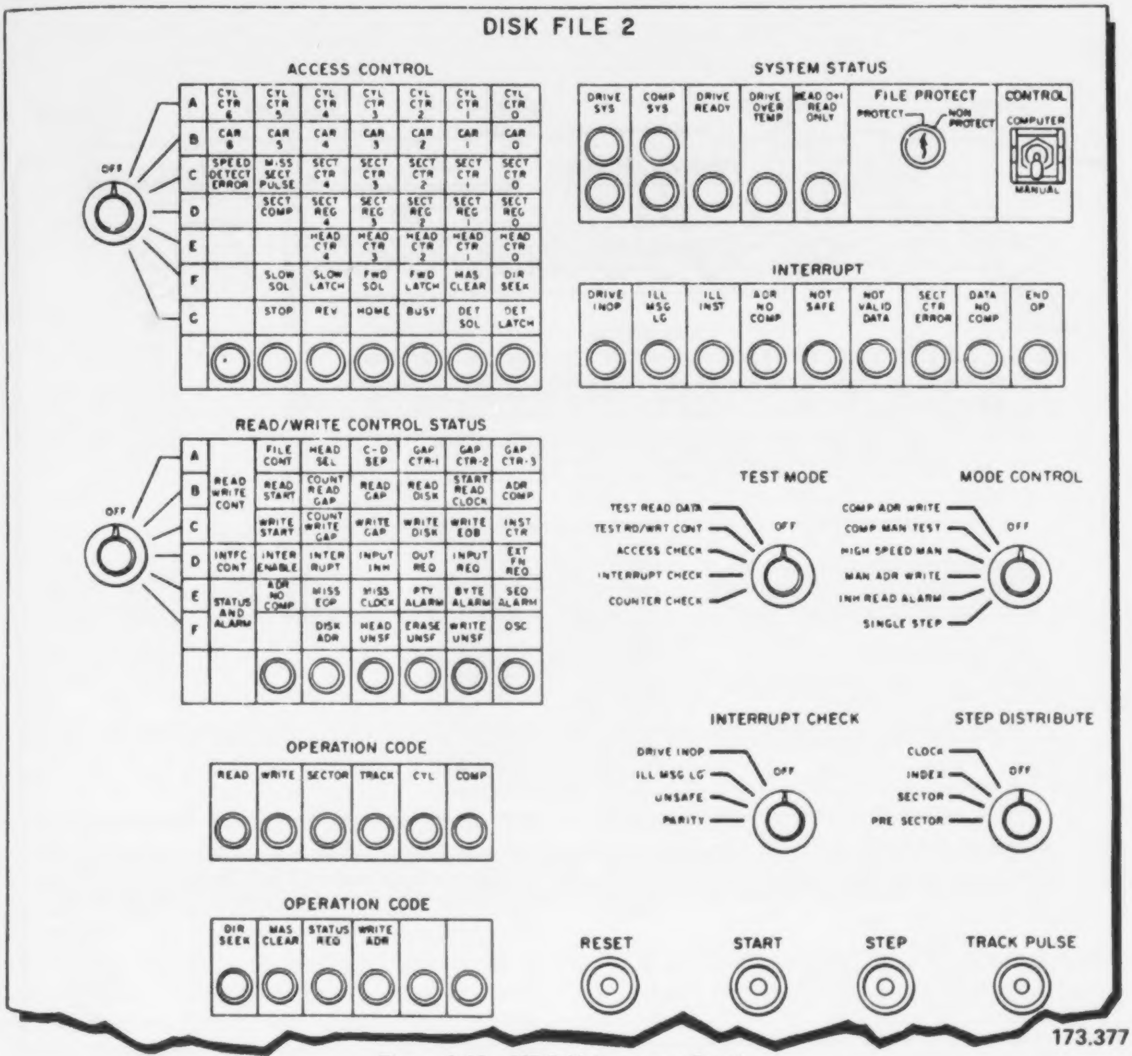
Each of these operations will be discussed in a chronological sequence during the following paragraphs.

Manual Controls

Before an MDF operation is initiated the operator must ensure that certain switches on the MDF MAINTENANCE PANEL, figure 4-41, are positioned for a specified operation. If an ACCESS or DATA TRANSFER operation is to be controlled by the DCC, the CONTROL switch, figure 4-41, must be placed in the COMPUTER position. If the operation is to be an ADDRESS WRITE or a test operation controlled from the DCC, the CONTROL switch is placed in MANUAL, and the MODE CONTROL switch is placed in either the COMP ADR WRITE or the COMP MAN TEST position, figure 4-41. When the CONTROL switch is placed in the COMPUTER position, the remaining panel switches are inhibited. When the CONTROL switch is placed in MANUAL, the MDF operations must be controlled locally through panel switches with the exceptions mentioned previously. Those exceptions were the ADDRESS WRITE and the computer controlled MDF test operations established by the MODE CONTROL switch.

If the operation is to be a WRITE data transfer, the key operated FILE PROTECT switch may require operation. When data is written at addresses that are protected, this switch must be placed in the NON-PROTECT position. For all other operations, it is common practice to leave it in PROTECT, although the switch only prevents the writing of new data.

When the MDF is operated in MANUAL, the type of MDF operation must be specified by setting up an instruction word by means of the INSTRUCTION ENTRY switches located at the bottom of the panel, figure 4-41. The operation can then be started by depressing the START pushbutton. This causes the instruction to be


DISK FILE 2
ACCESS CONTROL
OFF
A
B
C
D
E
F
G
CYL CTR 6
CYL CTR 5
CYL CTR 4
CYL CTR 3
CYL CTR 2
CYL CTR 1
CYL CTR 0
CAR 6
CAR 5
CAR 4
CAR 3
CAR 2
CAR 1
CAR 0
SPEED DETECT ERROR
MISS SECT PULSE
SECT CTR 4
SECT CTR 3
SECT CTR 2
SECT CTR 1
SECT CTR 0
SECT COMP
SECT REG 4
SECT REG 3
SECT REG 2
SECT REG 1
SECT REG 0
HEAD CTR 4
HEAD CTR 3
HEAD CTR 2
HEAD CTR 1
HEAD CTR 0
SLOW SOL
SLOW LATCH
FWD SOL
FWD LATCH
MAS CLEAR
DIR SEEK
STOP
REV
HOME
BUSY
DET SOL
DET LATCH
SYSTEM STATUS
DRIVE SYS
COMP SYS
DRIVE READY
DRIVE OVER TEMP
HEAD 0+1 READ ONLY
FILE PROTECT
PROTECT
NON PROTECT
CONTROL
COMPUTER
MANUAL
INTERRUPT
DRIVE INOP
ILL MSG LG
ILL INST
ADR NO COMP
NOT SAFE
NOT VALID DATA
SECT CTR ERROR
DATA NO COMP
END OP
READ/WRITE CONTROL STATUS
OFF
A
B
C
D
E
F
READ WRITE CONT
INTFC CONT
STATUS AND ALARM
FILE CONT
HEAD SEL
C-D SEP
GAP CTR-1
GAP CTR-2
GAP CTR-3
READ START
COUNT READ GAP
READ GAP
READ DISK
START READ CLOCK
ADR COMP
WRITE START
COUNT WRITE GAP
WRITE GAP
WRITE DISK
WRITE EOB
INST CTR
INTER ENABLE
INTER RUPT
INPUT INH
OUT REQ
INPUT REQ
EXT FN REQ
ADR NO COMP
MISS EOP
MISS CLOCK
PTY ALARM
BYTE ALARM
SEQ ALARM
DISK ADR
HEAD UNSF
ERASE UNSF
WRITE UNSF
OSC
TEST MODE
TEST READ DATA
TEST RD/WRT CONT
ACCESS CHECK
INTERRUPT CHECK
COUNTER CHECK
OFF
MODE CONTROL
COMP ADR WRITE
COMP MAN TEST
HIGH SPEED MAN
MAN ADR WRITE
INH READ ALARM
SINGLE STEP
OFF
INTERRUPT CHECK
DRIVE INOP
ILL MSG LG
UNSAFE
PARITY
OFF
STEP DISTRIBUTE
CLOCK
INDEX
SECTOR
PRE SECTOR
OFF
OPERATION CODE
READ
WRITE
SECTOR
TRACK
CYL
COMP
OPERATION CODE
DIR SEEK
MAS CLEAR
STATUS REQ
WRITE ADR
RESET
START
STEP
TRACK PULSE

173.377

Figure 4-41.—MDF Maintenance Panel.

loaded into the MDF INTERFACE (I/O) REGISTER.

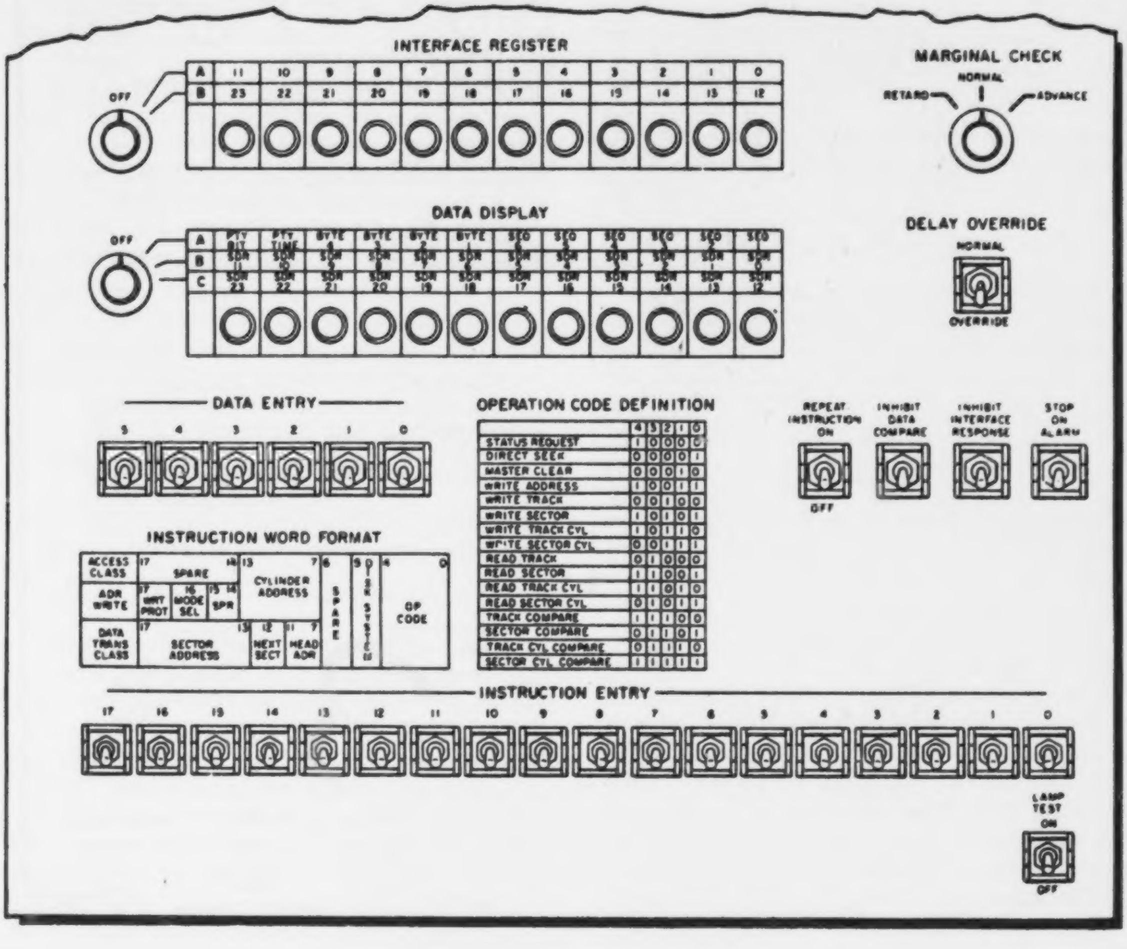
Access Operations

The purpose of an ACCESS operations is to position the read/write heads to an ordered cylinder position in the disk pack. There is no data transfer involved with this type of operation except the transfer of the instruction word and, in one case, the transfer of a current cylinder position status word.

The MDF is capable of performing four types of access operations most of which are also called SEEKS:

1. Automatic First Seek
2. Master Clear Seek
3. Direct Seek
4. Status Request

AUTOMATIC FIRST SEEK.—No instruction is associated with this type of operation. As the name implies, it is an


INTERFACE REGISTER
OFF
A 11 10 9 8 7 6 5 4 3 2 1 0
B 23 22 21 20 19 18 17 16 15 14 13 12
MARGINAL CHECK
NORMAL
RETARD
ADVANCE
DATA DISPLAY
OFF
A PTY BIT, PTY TIME, BYTE 4, BYTE 3, BYTE 2, BYTE 1, SEQ 5, SEQ 4, SEQ 3, SEQ 2, SEQ 1, SEQ 0
B SDR 11, SDR 10, SDR 9, SDR 8, SDR 7, SDR 6, SDR 5, SDR 4, SDR 3, SDR 2, SDR 1, SDR 0
C SDR 23, SDR 22, SDR 21, SDR 20, SDR 19, SDR 18, SDR 17, SDR 16, SDR 15, SDR 14, SDR 13, SDR 12
DELAY OVERRIDE
NORMAL
OVERRIDE
DATA ENTRY
5 4 3 2 1 0
INSTRUCTION WORD FORMAT
ACCESS CLASS
17 SPARE 14
13 CYLINDER ADDRESS 7
ADR WRITE
17 WRT PROT
16 MODE SEL
15 14 SPR
DATA TRANS CLASS
17 SECTOR ADDRESS 13
12 NEXT SECT
11 HEAD ADR 7
6 SPARE
5 DISK SYSTEM
4 OP CODE 0
OPERATION CODE DEFINITION
REPEAT INSTRUCTION ON
OFF
INHIBIT DATA COMPARE
INHIBIT INTERFACE RESPONSE
STOP ON ALARM
INSTRUCTION ENTRY
17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
LAMP TEST ON
OFF

OPERATION CODE DEFINITION

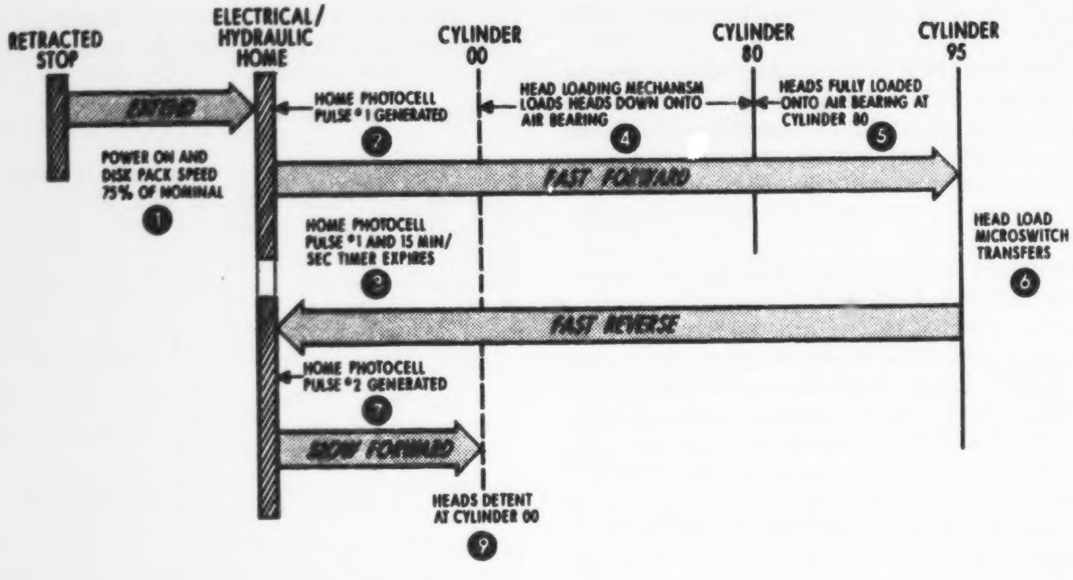
	4	3	2	1	0
STATUS REQUEST	1	0	0	0	0
DIRECT SEEK	0	0	0	0	1
MASTER CLEAR	0	0	0	1	0
WRITE ADDRESS	1	0	0	1	1
WRITE TRACK	0	0	1	0	0
WRITE SECTOR	1	0	1	0	1
WRITE TRACK CYL	1	0	1	1	0
WRITE SECTOR CYL	0	0	1	1	1
READ TRACK	0	1	0	0	0
READ SECTOR	1	1	0	0	1
READ TRACK CYL	1	1	0	1	0
READ SECTOR CYL	0	1	0	1	1
TRACK COMPARE	1	1	1	0	0
SECTOR COMPARE	0	1	1	0	1
TRACK CYL COMPARE	0	1	1	1	0
SECTOR CYL COMPARE	1	1	1	1	1

173.377

Figure 4-41.—MDF Maintenance Panel—Continued.

automatic operation that is initiated when power is first applied to the MDF equipment. The purpose of this operation is to load the read/write heads and place the carriage at a specific cylinder as a starting point for further operations.

As soon as power is applied to the MDF, the disk pack starts to rotate. When the sector pulses indicate that the pack speed is greater than 72% of nominal, figure 4-42, the carriage begins to move towards the pack and a 15-minute timer is started. The carriage will stop at the HOME


RETRACTED STOP
ELECTRICAL/ HYDRAULIC HOME
CYLINDER 00
CYLINDER 80
CYLINDER 95
EXTEND
HOME PHOTOCELL PULSE #1 GENERATED
②
HEAD LOADING MECHANISM LOADS HEADS DOWN ONTO AIR BEARING
④
HEADS FULLY LOADED ONTO AIR BEARING AT CYLINDER 80
⑤
POWER ON AND DISK PACK SPEED 75% OF NOMINAL
①
FAST FORWARD
HOME PHOTOCELL PULSE #1 AND 15 MIN/ SEC TIMER EXPIRES
③
HEAD LOAD MICROSWITCH TRANSFERS
⑥
FAST REVERSE
HOME PHOTOCELL PULSE #2 GENERATED
⑦
SLOW FORWARD
HEADS DETENT AT CYLINDER 00
⑨

173.378

Figure 4-42.—DDU Carriage Assembly Operation During Automatic First Seek.

position until the 15-minute timer expires. The 15-minute timer can be overridden by operating the DELAY OVERRIDE switch, figure 4-41, to the OVERRIDE position. This operation decreases the waiting time from 15 minutes to 15 seconds. However, it should be done only in accordance with current procedural documentation. The timers allow a delay so that the forced air can remove dust and moisture that may have accumulated in the pack. This must be done before the heads are loaded. Upon expiration of the timer, the carriage will proceed forward into the disk pack. At about cylinder 80, the heads should be fully loaded onto the air cushion above the disk surface. The carriage will continue to move to approximately cylinder 95 where the head load Microswitch, figure 4-33, should function, generating the signal HEADS EXTENDED. This will cause the cylinder access logic to order the carriage to move in reverse. The carriage will move in reverse until the HOME photocell pulse is generated, at which time the carriage will again change direction and move forward to the cylinder 00 position and detent. Upon satisfactory completion of this operation, the DRIVE READY indicator on the maintenance panel, figure 4-41, should light green.

MASTER CLEAR SEEK.—This operation positions the heads to a specified cylinder in preparation for a data transfer operation. The operation is initiated upon receipt of an access class instruction with a master clear OP CODE, figure 4-39. The MASTER CLEAR SEEK operation causes the carriage to move in reverse from its present position to the HOME position. Then the carriage is moved forward the number of cylinders specified by the count in the cylinder counter. As the carriage moves towards the ordered position, track pulses from the track photocell assembly count down the contents of the cylinder counter. The carriage speed will shift from fast to slow when the count is 9 or less. When the count is equal to zero, the carriage is one cylinder away from the ordered position. The next track pulse will detent the carriage.

At the completion of the operation, the numerical designation of the cylinder position is placed in a CURRENT ADDRESS REGISTER (CAR).

The MDF logic is designed to allow accessing of cylinder 100 to be initiated only from the maintenance panel. If an instruction from the DCC specifies cylinder 100, it is decoded as an illegal instruction and the operation will be aborted.

DIRECT SEEK.–This operation causes the heads to be positioned from their current location directly to the ordered cylinder. The operation is initiated by decoding the direct seek OP CODE, figure 4-39. Instead of placing the cylinder address bits of the instruction directly into the cylinder counter, as was the case with the MASTER CLEAR operation, the DIRECT SEEK operation causes the cylinder address to be fed to a DIFFERENCE GENERATOR circuit. The new cylinder address and the current contents of the CAR are algebraically summed in the DIFFERENCE GENERATOR and the result is then placed in the cylinder counter to specify how many cylinders the carriage must traverse for the operation. The carriage is then put in motion, and the track pulses begin to count down the contents of the cylinder counter. When the count in the counter is 10, the carriage speed will shift to SLOW. When the count is equal to 1, the cylinder address logic enables the next track pulse to detent the carriage.

If an instruction word from the DCC contains an address of cylinder 100, the operation will be aborted.

STATUS REQUEST.–The format of the instruction word associated with this operation is similar to the other access class instructions except the word contains only an OP CODE with no cylinder specified, figure 4-39. The purpose of the operation is to provide the DCC with the ststus of the DDU head carriage.

The operation causes an 18-bit status word to be transferred to the DCC. Bits 0-8 are not used. Bit 9 is set to denote a DRIVE INOPERATIVE status. Bit 10 denotes a DRIVE BUSY status. Bits 11-17 are used to inform the DCC of the present cylinder position of the carriage. The latter is obtained from the contents of the CURRENT ADDRESS REGISTER (CAR).

There is no access operation performed as a result of the STATUS REQUEST instruction.

Write Address Operation

The purpose of this operation is to place the address information on the disk surfaces. This operation is also referred to as the formatting operation. There is no access operation required prior to performing the write address operation, because accessing is one of the functions prescribed when a Write Address Instruction is decoded.

The Write Address Instruction, figure 4-39, will contain a cylinder address to specify where the carriage must be placed to begin the operation. The instruction word will also be performed in the TRACK or SECTOR mode. Also, the protect bit of the instruction will establish whether or not a logic 1 should be written at the bit 18 position of the address word on the disk.

Once the instruction has been decoded, the first part of the operation will be to access the heads to the cylinder prescribed by the instruction. The instruction word does not specify a head address, because the write address operation will always start at either surface 00 or 02. The operation begins at surface 00 if a READ 0+1 feature is not installed. This feature refers to the installation of jumper wires that force disk surfaces 00 and 01 to be read only. This feature will abort any write operation that is attempted on surfaces 00 or 01. An indication that the feature is installed is indicated by a READ 0+1 ONLY indicator in the MDF maintenance panel, figure 4-41.

With the feature installed, a WRITE ADDRESS operation would automatically begin with disk surface 02.

There are only two modes to the WRITE ADDRESS operation, (1) the TRACK CYLINDER mode and (2) the SECTOR CYLINDER mode.

Since the operation always begins with either surface 00 or 02 and continues on the same cylinder completely through all surfaces down to surface 19, the instruction word will simply define the track or sector mode. The cylinder feature of the operation is automatic.

If more than one cylinder is to be formatted, a new instruction will have to be received by the MDF for each cylinder requiring formatting.

Data Transfer Operations

A DATA TRANSFER operation is initiated when the MDF receives a data transfer class instruction, figure 4-39. The OP CODE of the instruction word will define not only the type of data transfer instruction but also the mode in which the instruction is to be executed.

There are three types of data transfer operations:

1. WRITE
2. READ
3. COMPARE

Each of the types of operations have four modes of execution:

1. TRACK
2. TRACK CYLINDER
3. SECTOR
4. SECTOR CYLINDER

Before the MDF receives a DATA TRANSFER instruction, it must have previously received and executed an ACCESS class instruction. The data TRANSFER operation does not include accessing the heads to a required position.

GENERAL DESCRIPTION.–The execution of the transfer instruction is performed in three phases called the:

1. instruction accept cycle
2. address compare cycle
3. instruction execution cycle

Instruction Accept Cycle.–This phase of the operation includes receiving the instruction, decoding the instruction, and sending the various address bits of the instruction to the address compare circuitry.

Address Compare Cycle.–This phase includes reading the addresses from the disk and comparing them with the address of the instruction word. One of the requirements for the successful completion of the address compare cycle is that bit 0 of the OP CODE of the instruction word, figure 4-39, must compare with bit 17 of the address written on the disk (fig. 4-27). These bits define either the TRACK mode (logic 0) or the SECTOR mode (logic 1). If these bits do not compare, the operation is aborted. When the addresses compare, the instruction execution cycle is initiated immediately. The address compare cycle is performed during both data read and data write operations.

Instruction Execution Cycle.–This phase refers to the operation that actually performs the placing or retrieving of the data bits onto or from the disk surface.

WRITE OPERATION.–The write operation is designated by bits 2 and 3 of the instruction OP CODE figure 4-39, when they represent a binary 01. The write operation can be started on any surface which is designated by the head address bits of the instruction. If the instruction also specifies a cylinder mode, the operation will begin on the surface designated by the head address and continue on the same cylinder, on each successive disk surface, until head 19 is reached. If the cylinder mode is not designated, the operation will begin and end on the same disk surface.

The SECTOR and TRACK designations of the mode of operation establish where on the given track the operation is to begin. In the track mode, the operation begins when the INDEX pulse occurs. In the sector mode, a particular count must be in the sector counter before the operation is started. The sector counter counts the pulses from the sector photocell. The count in the counter specifies the number of the sector currently passing under the read/write heads. It begins a new count every time the INDEX pulse occurs (see fig. 4-26). The transfer of write data from the DCC to the MDF begins upon successful completion of the address compare cycle. The data is transferred from the DCC to the MDF, one 24-bit word at a time (fig. 4-43). From the I/O register the data is

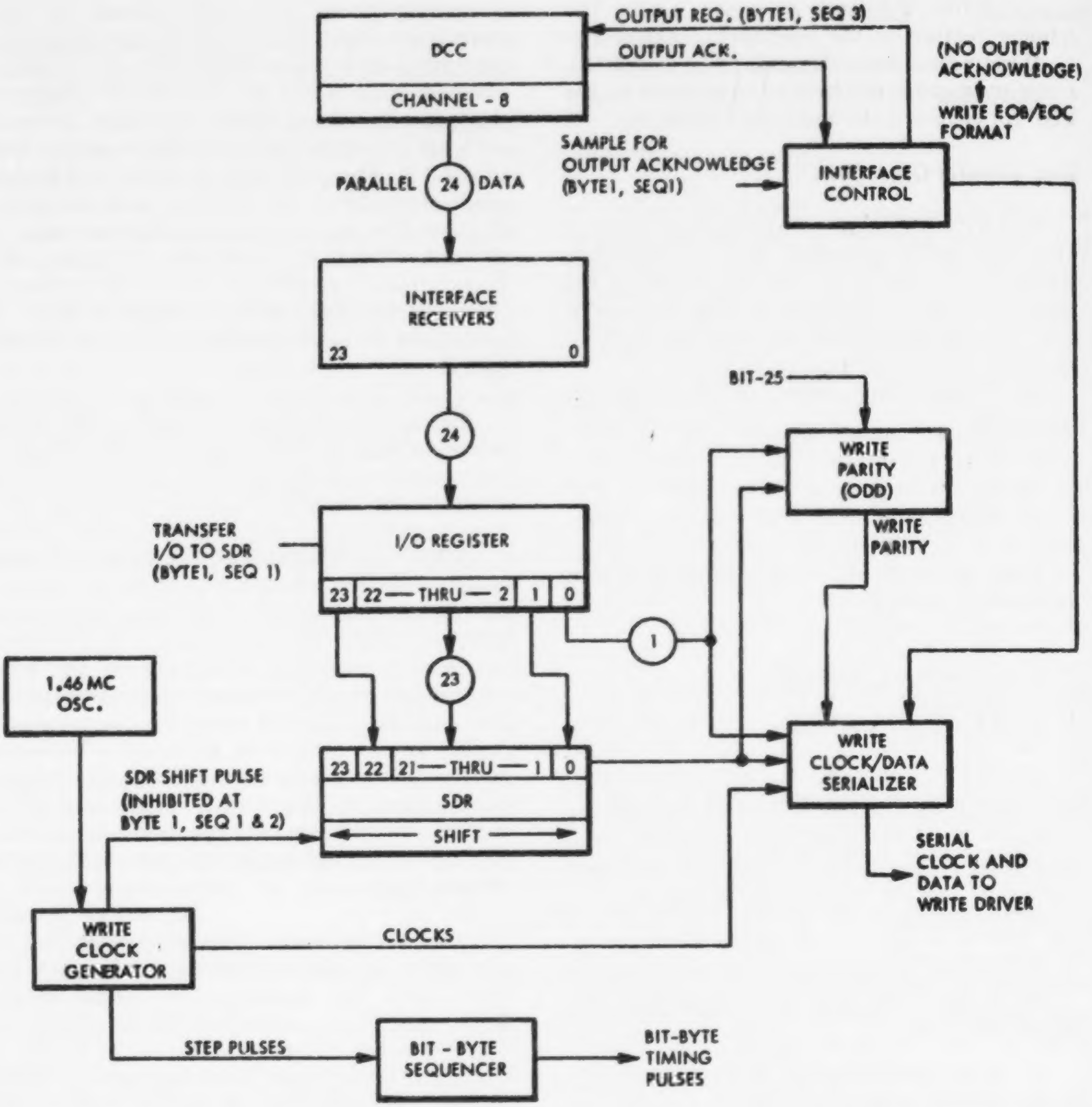
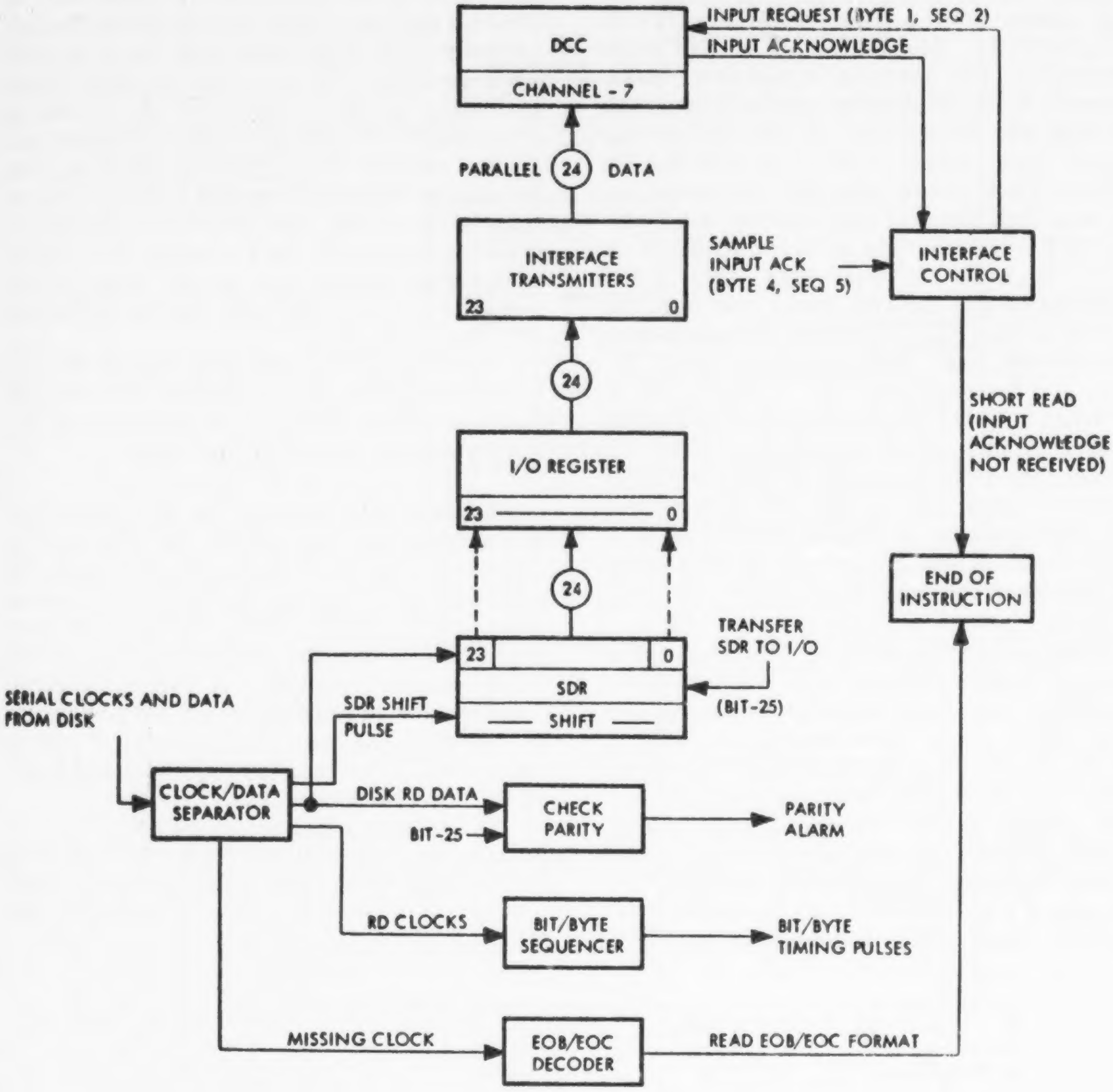

OUTPUT REQ. (BYTE1, SEQ 3)
DCC
OUTPUT ACK.
CHANNEL - 8
(NO OUTPUT ACKNOWLEDGE)
WRITE EOB/EOC FORMAT
SAMPLE FOR OUTPUT ACKNOWLEDGE (BYTE1, SEQ1)
INTERFACE CONTROL
PARALLEL
24
DATA
INTERFACE RECEIVERS
23
0
BIT-25
24
WRITE PARITY (ODD)
WRITE PARITY
TRANSFER I/O TO SDR (BYTE1, SEQ 1)
I/O REGISTER
23
22 — THRU — 2
1
0
1
23
1.46 MC OSC.
WRITE CLOCK/DATA SERIALIZER
SDR SHIFT PULSE (INHIBITED AT BYTE 1, SEQ 1 & 2)
23
22
21 — THRU — 1
0
SDR
SHIFT
SERIAL CLOCK AND DATA TO WRITE DRIVER
WRITE CLOCK GENERATOR
CLOCKS
STEP PULSES
BIT - BYTE SEQUENCER
BIT-BYTE TIMING PULSES
173.379

Figure 4-43.—Simplified Data Transfer Block Diagram (Write Instruction).

placed in the SDR. From the SDR the data is shifted serially to the CLOCK/DATA SERIALIZER. Clock pulses are also fed to the SERIALIZER, and both clock and write data bits are placed on the disk. The bit/byte sequencer is being stepped at a 730-kHz rate during this operation, and one clock and one data bit are written during each sequencer bit time. After 24 data bits are written, a parity bit is added to the data word on the disk. When the


DCC
CHANNEL - 7
INPUT REQUEST (BYTE 1, SEQ 2)
INPUT ACKNOWLEDGE
PARALLEL
24
DATA
INTERFACE TRANSMITTERS
23
0
SAMPLE INPUT ACK (BYTE 4, SEQ 5)
INTERFACE CONTROL
24
SHORT READ (INPUT ACKNOWLEDGE NOT RECEIVED)
I/O REGISTER
23
0
24
END OF INSTRUCTION
TRANSFER SDR TO I/O
23
0
SDR
SHIFT
(BIT-25)
SERIAL CLOCKS AND DATA FROM DISK
SDR SHIFT PULSE
CLOCK/DATA SEPARATOR
DISK RD DATA
BIT-25
CHECK PARITY
PARITY ALARM
RD CLOCKS
BIT/BYTE SEQUENCER
BIT/BYTE TIMING PULSES
MISSING CLOCK
EOB/EOC DECODER
READ EOB/EOC FORMAT

173.380

Figure 4-44.—Simplified Data Transfer Block Diagram (Read Instruction).

DCC stops sending data, the MDF will write a data EOB or an EOC code to complete the operation.

READ OPERATION.—An instruction accept cycle and an address compare cycle are performed, just as with the write operation, before the read operation is executed. The main difference between the read instruction and the write instruction is the code formed by bits 2 and 3 of the instruction OP CODE. The read operation is designated by a binary logic 0 in the bit 2 position and a binary logic 1 in the bit 3 position, figure 4-39. The read operation has four modes of execution; TRACK, TRACK CYLINDER, SECTOR, and SECTOR CYLINDER. The timing for a read data transfer operation is provided by the clocks written with the data bits on the disk. As the data is read from the disk, the CLOCK/DATA SEPARATION circuit separates the clocks and the read data. The read data is serially gated into the SDR, and the clocks are distributed as timing terms to the MDF logic. One of the functions of the 730-kHz clocks read from the disk is to step the BIT/BYTE sequencer at a 730-kHz rate, figure 4-44.

When a 24-bit data word is assembled in the SDR, it is then gated, in parallel, to the I/O register. The DCC then gates the data word over channel 7 input lines in the DCC I/O section. The read operation is continuous until an EOB or EOC code is read and decoded, at which time the operation is terminated.

COMPARE OPERATION.--This operation is partly a read operation and partly a write operation. Data is read from the disk and placed in the SDR. At the same time, a data word is sent to the DCC and placed in the I/O register, figure 4-45. Both data words are compared in a data compare circuit. This operation is utilized to verify that the data transfer of a previous read or write operation was performed correctly. For example, if a read operation was just performed, the DCC would initiate a compare operation to compare the data words it had just received with the source of the data words to ensure that the previous read operation had transferred the data correctly. The same holds true for a previous write operation. The compare operation begins with an instruction accept cycle and an address cycle just as the read and write operations did. Do not confuse the COMPARE operation with the address compare cycle that is part of all data transfer operations. The COMPARE operation is concerned only with DATA words. The address compare is simply one of the steps in the execution of the COMPARE and the READ and WRITE operations.

The timing and the step signals for the bit/byte sequencer are generated by the 730-kHz clocks read from the disk for this operation just as they were for the READ operation.

As you have noticed, we have gone into greater detail in some areas of the MDF and its associated circuitry. This was done primarily for two reasons, (1) the unique function of several of the MDF circuits, and (2) the relatively new application of the mass memory disk file to the FBM weapon systems. A good working knowledge of this subsystem will aid you greatly in operating and maintaining the MDF and in understanding its interface with the remainder of the Fire Control System.

The following chapter, POSEIDON Weapon System Operation, will discuss tactical operation of the MDF along with operator control and actions for a normal tactical sequence of the FBM weapon system.

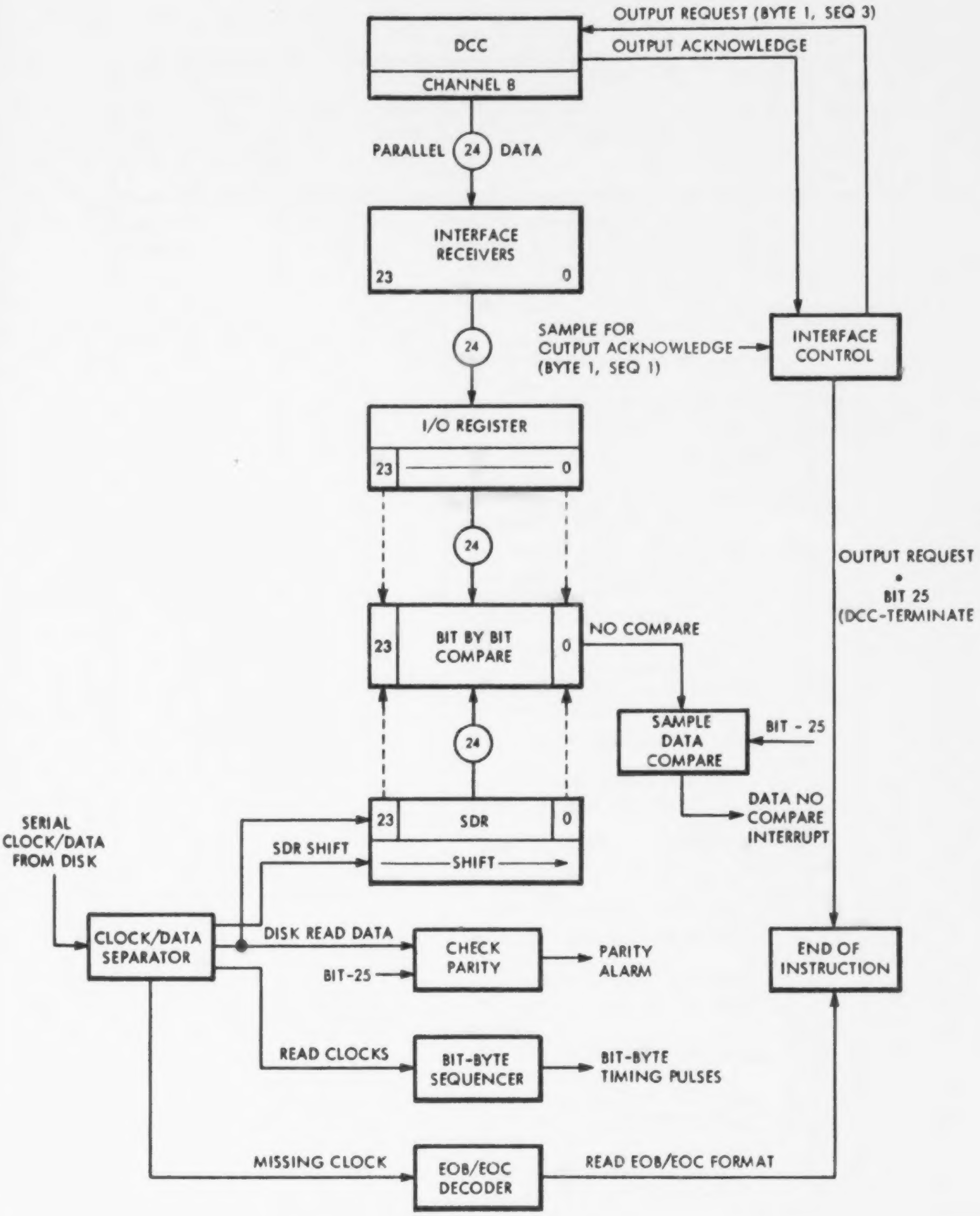

DCC
CHANNEL 8
OUTPUT REQUEST (BYTE 1, SEQ 3)
OUTPUT ACKNOWLEDGE
PARALLEL
24
DATA
INTERFACE RECEIVERS
23
0
24
SAMPLE FOR OUTPUT ACKNOWLEDGE (BYTE 1, SEQ 1)
INTERFACE CONTROL
I/O REGISTER
23
0
24
OUTPUT REQUEST
•
BIT 25
(DCC-TERMINATE
BIT BY BIT COMPARE
23
0
NO COMPARE
SAMPLE DATA COMPARE
BIT - 25
24
DATA NO COMPARE INTERRUPT
SERIAL CLOCK/DATA FROM DISK
SDR
23
0
SDR SHIFT
SHIFT
CLOCK/DATA SEPARATOR
DISK READ DATA
CHECK PARITY
BIT-25
PARITY ALARM
END OF INSTRUCTION
READ CLOCKS
BIT-BYTE SEQUENCER
BIT-BYTE TIMING PULSES
MISSING CLOCK
EOB/EOC DECODER
READ EOB/EOC FORMAT

Figure 4-45.—Simplified Data Transfer Block Diagram (Compare Instruction). 173.381

Table 4-1.—D

Mnemonic Code	Instruction Code f	Designator b	Execution Address	Operation	Address Modification Types			Executing Sequence
					IDX	IA	RA	
ARS	01	0-7	K	A Right Shift Shift (A) right K places, end-off. Sign bit is extended.	X	X		MDS
QRS	02	0-7	K	Q Right Shift Shift (Q) right K places, end-off. Sign bit is extended.	X	X		MDS
LRS	03	0-7	K	Long Right Shift Shift (AQ) right K places, end-off. Sign bit is extended.	X	X		MDS
ALS	04	0-7	K	A Left Shift Shift (A) left K places, end-around.	X	X		MDS
QLS	05	0-7	K	Q Left Shift Shift (Q) left K places, end-around.	X	X		MDS
LLS	06	0-7	K	Long Left Shift Shift (AQ) left K places, end-around.	X	X		MDS
ADD	10	0-7	M	Add Add (A) and (M). Sum is in A.	X	X	X	MA
SUB	11	0-7	M	Subtract Subtract (M) from (A). Difference is in A.	X	X	X	MA
MUI	12	0-7	M	Multiply Multiply (A) (M). Product is in AQ.	X	X	X	MA and MDS
DIV	13	0-7	M	Divide Divide (AQ) (M). Quotient is in Q; remainder is in A.	X	X	X	MA and MDS
INA	14	0-7	Y	Increase A Add Y + (A). Sum is in A.	X	X		ZA
INQ	15	0-7	Y	Increase Q Add Y + (Q). Sum is in Q.	X	X		AUX
ADQ	16	0-7	M	Add to Q (inhibit end-around carry) Add (M) + (Q). Sum is in Q. If end-around carry occurs on addition, the next instruction is performed; if no end-around carry occurs, the next sequential instruction is skipped.	X	X	X	AUX
LDL	20	0-7	M	Load Logical Product Form logical product of (Q) and (M); transfer result to A.	X	X	X	MA
CPA	21	Not Used	Not Used	Complement A Form complement of (A) and return result to A.				ZA
LAC	22	0-7	M	Load A Complement Form complement of (M) and transfer to A	X	X	X	MA
CPQ	23	Not Used	Not Used	Complement Q Form complement of (Q) and return result to Q.				ZA
SBA	24	0-7	M	Substitute Address Replace (M, bits 00 to 14) with (A, bits 00 to 14).	X	X	X	MA
SCM	25	0-7	M	Selective Complement Obtain (M) from memory. Complement bit (A_n) if corresponding bit $(M_n) = 1$.	X	X	X	MA
UJP	27	0-7	M	Unconditional Jump Jump to M for next instruction.	X	X	X	AUX
LDA	30	0-7	M	Load A Transfer (M) to A.	X	X	X	MA
LDQ	31	0-7	M	Load Q Transfer (M) to Q.	X	X	X	MA
STA	32	0-7	M	Store A Store (A) at memory location M.	X	X	X	MA
STQ	33	0-7	M	Store Q Store (Q) at memory location M.	X	X	X	MA

Table 4-1.—DCC Instruction Repertoire

Mnemonic Code	Instruction Code f	Designator b	Execution Address	Operation	Address Modification Types			Executing Sequence
					IDX	IA	RA	
		0-7	M	Add to Q (inhibit end-around carry) Add (M) + (Q). Sum is in Q. If end-around carry occurs on addition, the next instruction is performed; if no end-around carry occurs, the next sequential instruction is skipped.	X	X	X	AUX
		0-7	M	Load Logical Product Form logical product of (Q) and (M); transfer result to A.	X	X	X	MA
		Not Used	Not Used	Complement A Form complement of (A) and return result to A.				ZA
		0-7	M	Load A Complement Form complement of (M) and transfer to A	X	X	X	MA
		Not Used	Not Used	Complement Q Form complement of (Q) and return result to Q.				ZA
		0-7	M	Substitute Address Replace (M, bits 00 to 14) with (A, bits 00 to 14).	X	X	X	MA
		0-7	M	Selective Complement Obtain (M) from memory. Complement bit (A_n) if corresponding bit $(M_n) = 1$.	X	X	X	MA
		0-7	M	Unconditional Jump Jump to M for next instruction.	X	X	X	AUX
		0-7	M	Load A Transfer (M) to A.	X	X	X	MA
		0-7	M	Load Q Transfer (M) to Q.	X	X	X	MA
		0-7	M	Store A Store (A) at memory location M.	X	X	X	MA
		0-7	M	Store Q Store (Q) at memory location M.	X	X	X	MA
LAL	34	0-7	M	Load A Lower Transfer (M, bits 00 to 14) to (A, bits 00 to 14).	X	X	X	AUX
XAQ	35	Not Used	Not Used	Exchange A and Q Exchange contents of A and Q.				AUX
ENA	36	0-7	Y	Enter A Transfer Y to A, bits 00 to 14. Sign bit of Y is extended.	X	X		ZA
ENQ	37	0-7	Y	Enter Q Transfer Y to Q, bits 00 to 14. Sign bit of Y is extended.	X	X		ZA
AJP	40		M	A Jump			X	
		0		Jump to M if (A) = 0.				ZA
		1		Jump to M if (A) ≠ 0.				
		2		Jump to M if (A) positive.				
		3		Jump to M if (A) negative.				
		4		Return jump to M if (A) = 0.				MA
		5		Return jump to M if (A) ≠ 0.				
		6		Return jump to M if (A) positive.				
		7		Return jump to M if (A) negative.				
				Perform next instruction if jump condition is not met.				
SLJ	41		M	Selective Jump			X	
		0		Jump to M unconditionally.				ZA
		1		Jump to M if SELECTIVE JUMP set; perform next sequential instruction if SELECTIVE JUMP clear.				
		2		Stop. Jump to M on restart.				
		3		Stop if SELECTIVE STOP set; jump to M on restart. Jump to M unconditionally if SELECTIVE STOP clear.				
		4		Return jump unconditionally.				MA
		5		Return jump to M if SELECTIVE JUMP set. Perform next sequential instruction if SELECTIVE JUMP clear.				
		6		Stop. Return jump to M on restart.				
SLJ (Cont)				Selective Jump (Cont)				
		7		Stop if SELECTIVE STOP set; return jump to M on restart. Return jump to M unconditionally if SELECTIVE STOP clear.				MA
AJS	42		M	A Jump Stop				
		0		Stop if SELECTIVE STOP set; jump to M on restart if (A) = 0. If SELECTIVE STOP clear, jump to M immediately if (A) = 0.			X	ZA
		1		Stop if SELECTIVE STOP set; jump to M on restart if (A) ≠ 0. If SELECTIVE STOP clear, jump to M immediately if (A) ≠ 0.				
		2		Stop if SELECTIVE STOP set; jump to M on restart if (A) positive. If SELECTIVE STOP clear, jump to M immediately if (A) positive.				ZA
		3		Stop if SELECTIVE STOP set; jump to M on restart if (A) negative. If SELECTIVE STOP clear, jump to M immediately if (A) negative.				
		4		Stop if SELECTIVE STOP set; return jump to M on restart if (A) = 0. If SELECTIVE STOP clear, return jump to M immediately if (A) = 0.				MA
		5		Stop if SELECTIVE STOP set; return jump to M on restart if (A) ≠ 0. If SELECTIVE STOP clear, return jump to M immediately if (A) ≠ 0.				
		6		Stop if SELECTIVE STOP set; return jump to M on restart if (A) positive. If SELECTIVE STOP clear, return jump to M immediately if (A) positive.				MA
		7		Stop if SELECTIVE STOP set; return jump to M on restart if (A) negative. If SELECTIVE STOP clear, return jump to M immediately if (A) negative.				
				If jump conditions are not met, perform next sequential instruction.				

173.354

Table 4-1.—DCC Instruction Repertoire—Continued

Mnemonic Code	Instruction Code f	Designator b	Execution Address	Operation	Address Modification Types			Executing Sequence
					IDX	IA	RA	
JSI	43		M	Jump and Set Index		X	X	AUX
		0		Jump to M and reset interrupt lockout flip-flop.				
		1-7		Jump to M and transfer (P + 1) to B^b				
QJP	44		M	Q Jump				AUX
		0		Jump to M if (Q) = 0.				
		1		Jump to M if (Q) ≠ 0.				
		2		Jump to M if (Q) positive.				
		3		Jump to M if (Q) negative.				
		4		Return jump to M if (Q) = 0.				
		5		Return jump to M if (Q) ≠ 0.				
		6		Return jump to M if (Q) positive.				
		7		Return jump to M if (Q) negative.				
				If jump conditions are not met, perform next sequential instruction.				
QJS	45		M	Q Jump Shift			X	
		0-3		If (Q) negative, shift Q one place left and jump to M. If (Q) positive, shift Q one place left and perform next sequential instruction.				ZA
		4-7		If (Q) negative, shift Q one place left and return jump to M. If (Q) positive, shift Q one place left and perform next sequential instruction.				MA
SCQ	46	0-7	K	Scale AQ Shift (AQ) in long left shift, end-around, reducing K by one for each shift, until A, bit 22 ≠ A, bit 23 (quantity scaled) or until K is reduced to zero. 1. If b = 0, scaling is executed but resulting K is lost. 2. If (AQ) is initially scaled, K is transferred to index register B and scaling is not performed. 3. If (AQ) = ± 0, K is transferred to index register b and scaling is not performed.		X		AUX
SCQ (Cont)				Scale AQ (Cont) 4. If K = 0, index register b is cleared and scaling is not performed. 5. If K ≠ 0 and b ≠ 0, scaling is performed. When scaling is completed, the reduced K is transferred to index register b.				
EXF	47			External Function				EF
		0	Y	Select and activate I/O channels 1 through 6.				
		2	R	Select and activate I/O channels 7/8.				
		3	-	Transfer (C1) to A.				
		4	-	Transfer (C2) to A.				
		5	-	Transfer MDFSS interrupt word to A.				
		7	Y	Sense for condition specified by Y. If condition is present, skip next instruction; if condition is not present, execute next instruction.				
ENI	50	1-7	Y	Enter Index Transfer Y to index register b. No operation if b = 0.		X		AUX
INI	51	1-7	Y	Increase Index Add Y + (Bb) and transfer sum to Bb. No operation if b = 0.		X		AUX

IJP	52	1-7	M	Index Jump
				If (Bb) ≠ 0, reduce (Bb) by one and jump to M.
				If (Bb) = 0, perform next sequential instruction.
				If b = 0, no operation.
						X	X	AUX

ISK	53	1-7	Y	Index Skip If (Bb) ≠ Y, increase (Bb) by one and perform next sequential instruction. If (Bb) = Y, skip next sequential instruction. If b = 0, no operation.		X		AUX
ATI	54	1-6	Not Used	A to Index Transfer (A, bits 00 to 14) to Bb. No operation if b = 0.				AUX

Mne mon Cod
QTI
STI
LDI

Table 4-1.—DCC Instruction Repertoire—Continued

Instruction Code f	Designator b	Execution Address	Operation	Address Modification Types			Executing Sequence
				IDX	IA	RA	
			Scale AQ (Cont) 4. If K = 0, index register b is cleared and scaling is not performed. 5. If K ≠ 0 and b ≠ 0, scaling is performed. When scaling is completed, the reduced K is transferred to index register b.				
47			External Function				EF
	0	Y	Select and activate I/O channels 1 through 6				
	2	R	Select and activate I/O channels 7/8.				
	3	-	Transfer (C1) to A.				
	4	-	Transfer (C2) to A.				
	5	-	Transfer MDFSS interrupt word to A.				
	7	Y	Sense for condition specified by Y. If condition is present, skip next instruction; if condition is not present, execute next instruction.				
50	1-7	Y	Enter Index Transfer Y to index register b. No operation if b = 0.		X		AUX
51	1-7	Y	Increase Index Add Y + (Bb) and transfer sum to Bb. No operation if b = 0.		X		AUX

52	1-7	M	Index Jump
			If (Bb) ≠ 0, reduce (Bb) by one and jump to M.
			If (Bb) = 0, perform next sequential instruction.
			If b = 0, no operation.
					X	X	AUX

53	1-7	Y	Index Skip If (Bb) ≠ Y, increase (Bb) by one and perform next sequential instruction. If (Bb) = Y, skip next sequential instruction. If b = 0, no operation.		X		AUX
54	1-6	Not Used	A to Index Transfer (A, bits 00 to 14) to Bb. No operation if b = 0.				AUX

Mnemonic Code	Instruction Code f	Designator b	Execution Address	Operation	Address Modification Types			Executing Sequence
					IDX	IA	RA	
QTI	55	1-6	Not Used	Q to Index Transfer (Q, bits 00 to 14) to Bb. No operation if b = 0.				AUX
STI	56	0-7	M	Store Index Store (Bb) in lower 15 bits of memory location M. Store 0's in lower 15 bits of M if b = 0.		X	X	AUX
LDI	57	0-7	M	Load Index Obtain (M) from memory. Transfer (M, bits 00 to 14) to Bb. If b = 0, no operation.		X	X	AUX

173.354

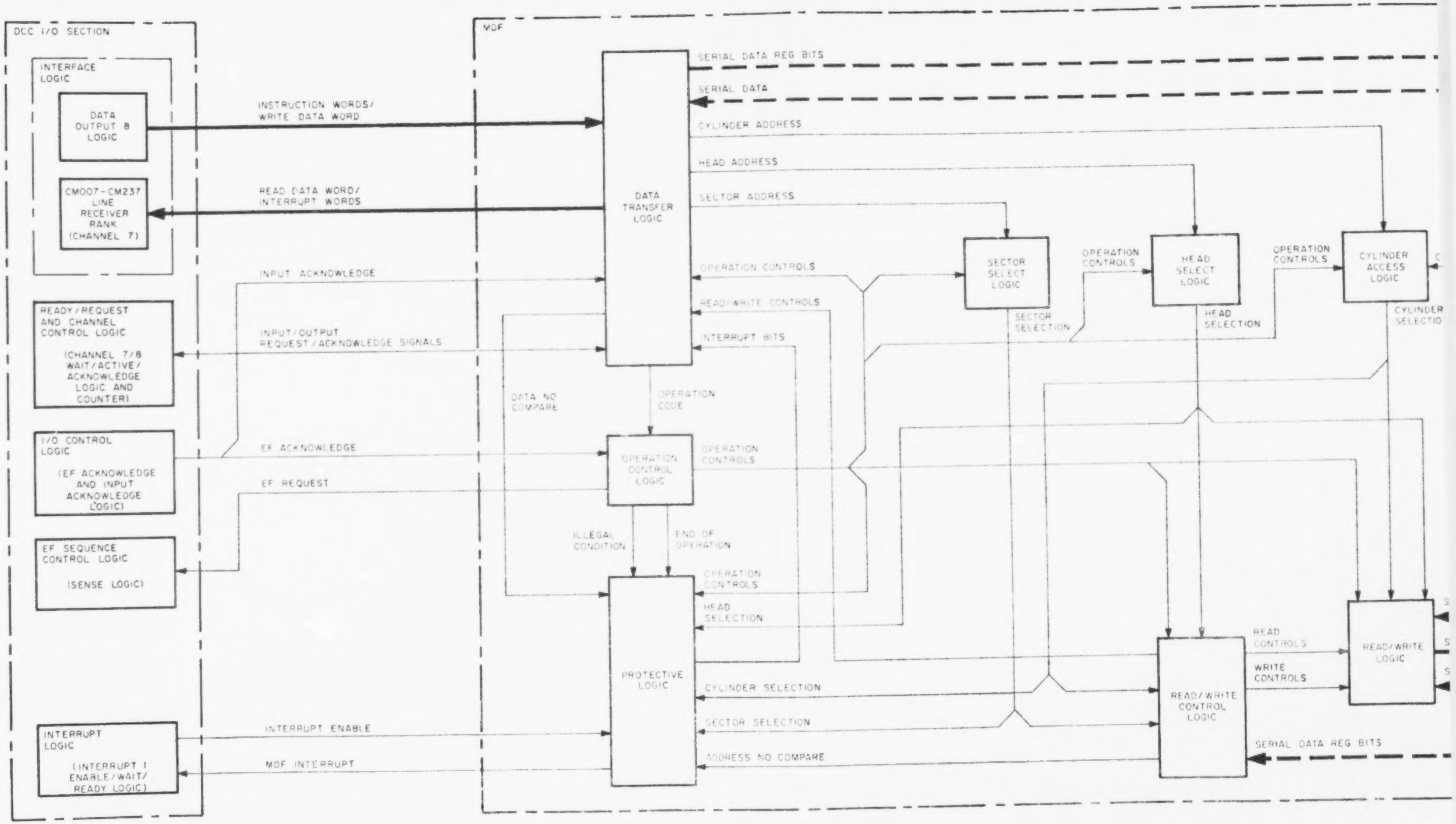
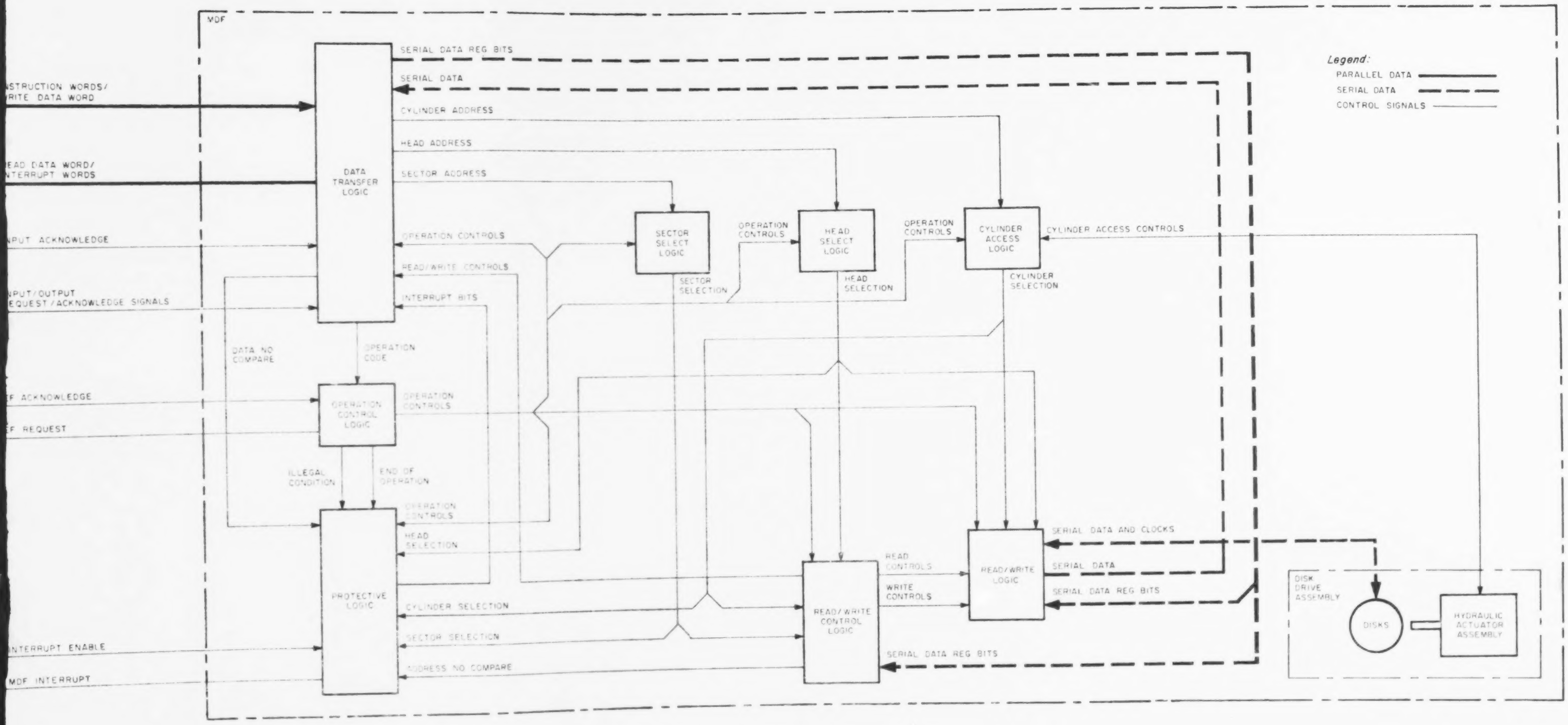

DCC I/O SECTION
INTERFACE LOGIC
DATA OUTPUT 8 LOGIC
CM007-CM237 LINE RECEIVER RANK (CHANNEL 7)
READY/REQUEST AND CHANNEL CONTROL LOGIC (CHANNEL 7/8 WAIT/ACTIVE/ ACKNOWLEDGE LOGIC AND COUNTER)
I/O CONTROL LOGIC (EF ACKNOWLEDGE AND INPUT ACKNOWLEDGE LOGIC)
EF SEQUENCE CONTROL LOGIC (SENSE LOGIC)
INTERRUPT LOGIC (INTERRUPT I ENABLE/WAIT/ READY LOGIC)
MDF
INSTRUCTION WORDS/ WRITE DATA WORD
READ DATA WORD/ INTERRUPT WORDS
INPUT ACKNOWLEDGE
INPUT/OUTPUT REQUEST/ACKNOWLEDGE SIGNALS
EF ACKNOWLEDGE
EF REQUEST
INTERRUPT ENABLE
MDF INTERRUPT
DATA TRANSFER LOGIC
SERIAL DATA REG BITS
SERIAL DATA
CYLINDER ADDRESS
HEAD ADDRESS
SECTOR ADDRESS
OPERATION CONTROLS
READ/WRITE CONTROLS
INTERRUPT BITS
DATA NO COMPARE
OPERATION CODE
OPERATION CONTROL LOGIC
OPERATION CONTROLS
ILLEGAL CONDITION
END OF OPERATION
PROTECTIVE LOGIC
OPERATION CONTROLS
HEAD SELECTION
CYLINDER SELECTION
SECTOR SELECTION
ADDRESS NO COMPARE
SECTOR SELECT LOGIC
SECTOR SELECTION
OPERATION CONTROLS
HEAD SELECT LOGIC
HEAD SELECTION
OPERATION CONTROLS
CYLINDER ACCESS LOGIC
CYLINDER SELECTIO
READ/WRITE CONTROL LOGIC
READ CONTROLS
WRITE CONTROLS
READ/WRITE LOGIC
SERIAL DATA REG BITS

Figure 4-38.—MDF Controller Block Diagram.


MDF
NSTRUCTION WORDS/
RITE DATA WORD
EAD DATA WORD/
NTERRUPT WORDS
NPUT ACKNOWLEDGE
NPUT/OUTPUT
EQUEST/ACKNOWLEDGE SIGNALS
F ACKNOWLEDGE
F REQUEST
NTERRUPT ENABLE
MDF INTERRUPT
DATA TRANSFER LOGIC
SERIAL DATA REG BITS
SERIAL DATA
CYLINDER ADDRESS
HEAD ADDRESS
SECTOR ADDRESS
OPERATION CONTROLS
READ/WRITE CONTROLS
INTERRUPT BITS
DATA NO COMPARE
OPERATION CODE
OPERATION CONTROL LOGIC
OPERATION CONTROLS
ILLEGAL CONDITION
END OF OPERATION
PROTECTIVE LOGIC
OPERATION CONTROLS
HEAD SELECTION
CYLINDER SELECTION
SECTOR SELECTION
ADDRESS NO COMPARE
SECTOR SELECT LOGIC
SECTOR SELECTION
OPERATION CONTROLS
HEAD SELECT LOGIC
HEAD SELECTION
OPERATION CONTROLS
CYLINDER ACCESS LOGIC
CYLINDER SELECTION
CYLINDER ACCESS CONTROLS
READ/WRITE CONTROL LOGIC
READ CONTROLS
WRITE CONTROLS
SERIAL DATA REG BITS
READ/WRITE LOGIC
SERIAL DATA AND CLOCKS
SERIAL DATA
SERIAL DATA REG BITS
DISK DRIVE ASSEMBLY
DISKS
HYDRAULIC ACTUATOR ASSEMBLY
Legend:
PARALLEL DATA
SERIAL DATA
CONTROL SIGNALS

173.374

Figure 4-38.—MDF Controller Block Diagram.

CHAPTER 5

POSEIDON WEAPON SYSTEM OPERATION

In this chapter, the operation of the POSEIDON weapon system will be discussed from the viewpoint of FTBs. As an FTB, it is important that you understand the concepts of operation and the interface relationship between the system, yourself, and other operators. This subject matter will help to give you insight into the problems of operating a weapon system within an FBM environment and the need for skilled technicians and operators in solving these problems.

This chapter is divided into two sections, prepatrol operations and patrol operations. The section on prepatrol operations includes refit maintenance and testing, sea trial operations, and final prepatrol readiness operations. The section on patrol operations includes normal preventative maintenance, testing, and a tactical countdown that includes casualty operation procedures and basic logkeeping.

POSEIDON WEAPON SYSTEM DOCUMENTATION

In order to operate and maintain the POSEIDON weapon system and the fire control system, it is important that you have a knowledge and understanding of the publications that provide the basic information for preventative maintenance, casualty procedures, and operation. As a working technician, you will become familiar with NAVORD OP 3804 (and associated volumes and parts), titled FIRE CONTROL SYSTEM, POSEIDON, MK 88 MOD 1. This publication is the prime OP for our fire control system.

Proper Use of OP 3804

After you have some experience in the system, the use of OP 3804 will be commonplace. In the meantime, some explanation will enable you to use the various volumes properly.

OP 3804 INDEX provides an alphanumeric list for locating information in the eleven volumes of OP 3804. At your first opportunity, study the INTRODUCTION. Learn the organization of the index, and get an idea of how the subjects are listed. The following will give you an example of subject-matter breakdown and the listing of information under a specific subject.

Assume that you need to check the nominal operating procedures of the fire control tactical launch as shown in OP 3804.

First, find the broad listing of "fire control" in the index. Second, find "nominal operating procedures" listed under fire control. (These broad listings are examples of what you need to know before you can use the index efficiently.) **Third, find "tactical launch". This is shown on page 2-116 of OP 3804 as:**

TACTICAL LAUNCH 3/02/03-037

This indicates that in volume 3/ part 2/ page 3-37 there will be information concerning the tactical launch. The index will also get you into the FCDs (functional circuit diagrams).

If you were troubleshooting the erection subsystem and needed to get into the FCDs, you could use the index in two different ways.

Under the alphanumeric design with erection as the subsystem, and FCD as the desired subject, you will find vol. 7, part 2, NAVORD drawing #2829203 as the location. The last three digits of the drawing, 203, are used for simplicity. In the section of the designated publication under the tab for 203, the FCDs for the ESS are found.

Another method of locating the proper OP for use in troubleshooting the erection subsystem is to look on the GENERAL CONTENTS sheet of the index. Under heading VOL 7, FUNCTIONAL CIRCUIT DIAGRAMS, PART 2, it lists ESS - 203, indicating the proper location of the FCDs with the last three digits of the drawing number.

Procedural Documentation

This is a term that is applied to system maintenance and operating procedures that are arranged in a step-by-step sequence so as to impose a specific, methodical order of accomplishment by the technician. This discipline is required because of the complexity of both the weapon system and the fire control system. NAVORD OD 43144, STANDARD OPERATING PROCEDURES, is a series of publications designed to provide procedural documentation for use by technicians aboard POSEIDON ships. The standard operating procedures were prepared to provide operation within the following guidelines:

To satisfy the nuclear weapons safety requirements for procedures as specified in OPNAV 8020.9 series, and, to provide a single source of detailed procedures to aid in operating and maintaining the weapon system at a high level of readiness and training.

One section of NAVORD OD 43144 consists of Procedural Guides (PG), the use of which is mandatory during specific operations. The purpose of a procedural guide is to coordinate major evolutions which involve many tasks and procedures. Each PG consists of a list of equipment required in accomplishing specific tasks, a list of the procedures that are needed in accomplishing specific tasks, and a checkoff type of procedure that governs the order in which these specific tasks must be accomplished in the performance of the major evolutions. Each PG also includes the tests required and the documentation (logging, etc.) requirements. PGs refer to Weapon Operating Procedures (WP) and to Standard Maintenance Procedures (SMP) as sources of individual task procedures. The Preventative Maintenance Management Plan (PMMP) may be referred to in the portion on documentation. Chapter 7 of this manual pertains.

You will become very familiar with procedural documentation in your duties as a fire control technician. We will make references to some of the documentation in this chapter when the tactical countdown is discussed.

REFIT MAINTENANCE AND TESTING

Refit maintenance and testing usually is started by the on-crew on their way into port from the patrol area. At this time, the weapon system and the fire control system are placed in a lower state of readiness called condition 4SQ, in accordance with PG8, TRANSITION FROM PATROL TO INPORT, WP 130, Fire Control Conditions of Readiness. PG8 directs the accomplishment of certain procedures, such as removal of the deployment disk pack from the MDFs and reinsertion of the duty disk packs, flight control loop test, flight control sequencer test, and valve test, as well as the verification that all patrol data has been gathered and all logs have been appropriately documented prior to entering port. PG2, TENDER AVAILABILITY PRE SEA TRIAL OPERATIONS, must be accomplished after the provisions of PG8 have been completed.

Fire Control System General Maintenance and Testing

The last week of the patrol cycle starts the routine testing of fire control equipment and missile-to-fire control interface circuit testing such as DRISS, erection, missile motion, etc. Upon entering port for the upkeep/availability, all portable test equipment such as oscilloscopes, meters, etc., are taken to the tender for recalibration and recertification to ensure the accuracy and reliability of each piece.

This equipment is used to certify, through testing, the different fire control equipment and interface between fire control and navigation, fire control to launcher and missile, and fire control to the Mk 113 torpedo fire control system. Such PMMPs that direct the conduct of an SMP to "perform velocity transmission and MMC static performance test" and "perform roll, pitch, and heading static transmission test" certify interface integrity between the various subsystems of the fire control system and other weapon system related equipments and navigation equipment.

After all interface and subsystem accuracy and reliability have been certified, the onboard missiles are certified. Each subsystem is tested and, finally, the guidance assembly and guidance computer are certified. This detailed testing is designed to detect and localize any abnormal trends or inaccuracies. It also ensures that the system and the missiles are at the highest condition of readiness required for a successful launch and flight to the selected targets.

Sea Trial Operations

Sea trial operations are a further step in the overall certification of the weapon system, fire control system, and missiles. PG3, titled SEA TRIAL OPERATIONS, dictates the selected operations required for sea trials from under way for sea trials through return to port. Condition 2SQ for sea trials is set throughout the weapon system.

PROCEDURES.–The major evolutions prescribed for sea trials are launcher readiness test, weapons system readiness test and dummy exercise. These evolutions serve a two-fold purpose: to check out both weapons department personnel, and to test all of the equipment and subsystems. Any real casualties may be combatted and corrected during this period. Additionally, the crew is trained on real or inserted casualties, training that is as close to a tactical situation as it is possible to get.

At the conclusion of sea trials, weapons condition 4SQ is again set, and the ship returns to port for final testing and readiness procedures prior to a normal patrol period.

Post Sea Trial Operations

Tender Availability Post Sea Trial Operations in accordance with PG4 are conducted to ensure that maximum readiness will be attained prior to actual deployment for a tactical patrol. During this period, detailed testing and maintenance is conducted to ensure that all equipment and missiles are ready in all respects.

PROCEDURES.–This time frame allows for the following evolutions/operations to be conducted:

Fuze set test–to check ability of proper fuze set commands and response.

Computer startup–This includes the procedures and operations to update the proper disk packs with GUPEL data, target data, guidance data, G/A-to-missile assignments, etc.

MTRE Mk 7 verification.

Of course, other tests in addition to routine daily and weekly PMMPs are conducted, but they are too numerous to list and explain in this manual.

At the conclusion of post sea trial testing and maintenance, all system, subsystem, and missile tests should be successfully completed, and all current data should be entered into the DCCs. The system and the personnel should be ready to go on patrol.

PATROL OPERATIONS

Normal patrol operations consist of routine PMMPs to keep the equipment operating normally and to detect any trends in degradation. These routine PMMPS consist of daily tests of the fire control system, subsystems, and missile tests. These routine PMMPs ensure that the fire control system and the missiles are maintained in the highest possible state of readiness.

At times, the commanding officer will initiate a WSRT (weapons system readiness test) to check the entire weapon system and ship's personnel. This is as close to an actual tactical launch as can be conducted without going through with the launch.

The remainder of this chapter is devoted to the functions performed by the weapons department personnel and the operation of the weapon system during a full tactical launch. NAVORD OD 43482, SSBN OFFICER'S GUIDE FOR POSEIDON WEAPON SYSTEM, will be used as a guide for methodology procedures and manning requirements in this discussion.

Tactical Launch Procedures

The tactical launch procedure starts with the 1MC announcement MAN BATTLE STATIONS MISSILE FOR STRATEGIC LAUNCH. This announcement directs all ship's personnel to man their battle stations and causes certain functions to commence at key control stations throughout the ship. Those functions that are required to effect a tactical launch will be discussed along with the weapon system procedures. Remember that the ship is at sea and in the patrol area. The weapon system is in condition 2SQ, that is the submarine is within range of targets assigned. The weapon system is "lined-up" in accordance with the provisions of PG5, TRANSITION FROM IN-PORT TO PATROL.

BATTLE STATION ASSIGNMENTS.–Battle station assignments are made using the recommendations from OD 43482 and OD 43144 requiring a full allowance of FBM weapons trained personnel, supplemented by nonweapons personnel as required in order to man a full team. Table 5-1 lists the recommended personnel assignments for the key weapons control stations onboard. Sometime during your tour of duty onboard an FBM submarine, you may expect to man those stations normally assigned to FTBs such as OAG, MTRE Mk 6, DGBC, and F/C group operator.

COMMUNICATIONS.–One of the fundamental elements of a successful tactical launch (or any other weapon system evolution) is proper communications. Good communications are achieved only by proper organization of circuits, rigid discipline that is constantly enforced, standard and concise phraseology for reports during time-sensitive operations, and a pre-determined knowledge of information flow, priorities, and required reports. Refer to table 5-1. Notice the columns labeled Circuit and Circuit Call. The key control stations are on the sound-powered phone circuit 10JC. The remainder of the weapons department is on the sound-powered phone circuit X43J. Additional key events or casualty problems are announced on the 35MC from the missile control center to the missile compartment. Other reports or commands are given verbally. Proper phraseology is maintained at all times.

SHIP'S PROCEDURES.–The ship will be placed immediately in a launch attitude at a designated launch depth and preparations will be made to hover. At the same time as the weapons personnel are manning their battle stations, the remainder of the crew are manning stations such as in engineering spaces to ensure the optimum line-up of machinery to support a tactical launch. Ship's control personnel are in position to place the ship in a hovering attitude and to compensate for the launch when necessary. Personnel man sound-powered phones in every compartment to monitor continuously for any abnormal event that could detract from the overall mission of the ship and the tactical launch of POSEIDON missiles.

FIRE CONTROL PROCEDURES.–The fire control procedures covered here must be followed by the FTBs in changing the fire control equipment from the patrol condition to the tactical launch condition (2SQ to 1SQ) and to sequence the missiles through the denote, assign, prepare, and launch operations. The fire control system will normally be in the MCC STANDBY mode unless scheduled maintenance or testing is being performed. With the system in the MCC STANDBY mode, the control console will be as illustrated in figure 5-1 (fold-in at the end of chapter). It is important that you recognize the color definitions of the actuator/indicators on the control console. Table 5-2 provides you with the proper indication color definition as we use them in the fire control system. You should learn them to facilitate your understanding of system operation as we progress through the chapter.

Table 5-1.—Strategic Launch, Recommended Personnel Assignments

Designation	Assignment	Circuit	Circuit Call
CONN	Commanding Officer	10JC	CONN
WPNS	Weapons Officer	10JC	Weapons
NAV	Navigator	10JC	NAV
AWEPS	Launcher Officer	10JC	Launcher
SUPR	Fire Control Supervisor	10JC	Supervisor
ITOP	ITOP Operator/35MC Announcer	35MC/ X43J-2	ITOP
COMP	DGBC and F/C Group	10JC/ X43J-3	Computer
OPTICS	Optical Alignment Group Operators (2)	10JC	Optics
SWBD	MC Switchboard Operator	10JC	Switchboard
MTRE 6	MTRE Mk 6 Operator	10JC/ X43J-3	MTRE 6
MTRE 7	MTRE Mk 7 Operator	10JC	MTRE 7
LCHR	Launcher Supervisor	X43J-2	Launcher
LCP 1/2	Launcher Control Panel Operators (2)	Verbal	LCP 1/2
GDNC (PORT/ STBD)	Upper Level Tube Teams (three men each)	X43J-2	Guidance (Port/Stbd)
MSLE	Middle Level Technician	Verbal	Missile
MCLL (PORT/ STBD)	Lower Level Tube Teams (two men each)	X43J-2	Lower Level (Port/Stbd)
NAV 1	Navigation Technician	X43J-3	NAV 1
DIVE	Diving Officer	Verbal	Dive
ADIVE	Assistant Diving Officer	Verbal	ADive
COW	Ballast Control Panel Hovering Operator	Verbal	Chief of the Watch
COMP	Ballast Control Panel Compensation Operator	X43J-2/ Verbal	COMP

Table 5-2.—Panel Indicator Color Definitions

Color	Definition
White	Indicates manual operator action has been taken by depressing an A/I (system mode, command slew, interrogate, hold, bypass, or manual fire mode) or equipment status is in an alternate condition (surface launch, local OAG control, next-to-fire signal to OAG, and missile away).
Blue	Indicates operator action required, generally by depressing the A/I (initiate fire, channel inhibit, denote clear, channel timing, assign clear, or DRISS reset).
Yellow	Indicates the event or status identified is not complete or is in a state of transition (MCC power, TMPS, coarse align, erection, MC 1SQ, channel check, channel inhibit, denote action complete, MC ready, OAG ready, fine align servos, align check, fine align, prepare to fire, missile prepared, MC prepared, and intent to fire).
Green	Indicates the event identified or status monitored has occurred or is completed.
Red	Indicates a general alarm condition where emergency operation or corrective action steps must be taken. Either a required function is absent or the monitored event exceeded specified time limits. NOTE: As required by its location in the Attack Center, all ACP indications are red.
Out	The function or status monitored is not required or has not yet been initiated.

Control Console Indications.—Refer to figure 5-1. During the description of the indications, we will establish the proper fire control indications for condition 2SQ. Indications should be as follows:

MCC:

Door Temp (green)—indicates that no post FLUE TEMP alarm exists in the MCC.

POWER (green)—indicates that no post power summary alarms exist in the fire control system excluding the 040 island group.

STATUS & POWER SWITCHES (green)—indicates that all motor-driven switches are correctly positioned for the system mode selected.

STATIONS REPORTS:

NAV (green)—indicates that all NavData switches are in the simulate mode.

OAG (red)—alarm indication is given because power is secured at the OAG during MCC standby mode.

CLOCK AND TIMING:

ACTIVE CLOCK (green)—indicates clock pulses are being generated by the clock supporting the master clock and timing subsystems.

ERECTION AND TEST TIMING (green)—an erection alarm condition is inhibited in this mode of operation.

STANDBY CLOCK (green)—indicates clock pulses are being generated by the auxiliary clock.

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COMPUTER (DCC1 and DCC2):

DCC (green)–indicates that DCC operations are normal.

ALERT (green)–indicates that no alarm printouts have originated at the DCC. In the event of an alarm, the ALERT indicator turns red until completion of the printout.

TARGET DATA (green)–indicates that the keylock on the keyboard and the MDF are in the protect position, and the DCC program has not detected a new target data entry which is unacknowledged.

DCC POWER (green)–indicates no post power alarm at 040/041 or 044/045.

DISK FILE POWER (green)–indicates no post power alarm from door post 047/046.

DGBC GROUP POWER (green)–indicates no power alarm from door posts 042C11, C18, or D15.

EARTH'S RATE:

LYO CHAN 1 (green)–indicates LYO servo at 052B08 is nulled, Earth's Rate switch in NORMAL or all to LYO 1 (2).

LYO CHAN 2 (green)–indicates LYO servo at 054B08 is nulled, Earth's Rate switch in NORMAL or all to LYO 2 (1).

INTERROGATE:

Missiles 1 through 16 (red)–alarm indication results from an erection alarm (MISSILE REPORTS/ERECTION) and the lack of missile normal (MISSILE REPORTS/DCC) from the DCC in this mode.

HOLD:

Missiles 1 through 16 (red)–alarm indication results from loss of digital erection assembly, because power distribution tactical switch is OFF in this mode.

BYPASS:

Missiles 1 through 16 (white)–a manual bypass exists for each of the 16 missiles.

CHAN 1 (2) INHIBIT (blue)–alarm indication results from removal of tactical power from DRISS in this mode.

DENOTE (channel 1 and channel 2):

DENOTE CLEAR (green)–indicates that all missile denote switches at the MC switchboard are in the OFF position.

ASSIGN (channel 1 and channel 2):

TIMING (green)–indicates channelized master timing from active clock is normal.

ASSIGN CLEAR (green)–indicates that all MC assign, MCC assign, and missile select switches are in the OFF position.

POWER (green)–indicates channelized power is normal.

DRISS RESET (blue)–alarm indication results from removal of tactical power from DRISS in the MCC standby mode.

HOLD (red)–alarm indication results from removal of tactical power from DRISS in the MCC standby mode.

All other indications on the control console are not lighted in the MCC standby mode of operation. Other indications located on the various door posts are monitored by the operator for the proper indication of the selected mode of operation.

Fire Control Supervisor Actions.–With the fire control system in 2SQ and the indications as noted above, the fire control supervisor upon the command to MAN BATTLE STATIONS MISSILE FOR STRATEGIC LAUNCH will verify the DCC to Equipment Configuration Panel and verify that his associate MCC watchstander enables ICL Transfer in accordance with the COMP (computer) procedures of the operating procedures. The supervisor releases the missile bypasses on all applicable missiles as directed by CONN and then selects TRAINING WITH GUIDANCE SYSTEM mode of operation and energizes the control console printer. He monitors each missile continuously for normal "spin-up" of the guidance systems and subsequent events by depressing the INTERROGATE (A/I) actuator/indicators. He will also verify that the FIRING ORDER patch panel is correct. This ensures that the selected missiles are sequenced through the channels in the preselected order for tactical launch.

The major indications that change during the supervisor's actions are listed below. Figure 5-1 will help you by showing the indications and A/Is that must change during the progression of the system to 1SQ.

BYPASS:

Depressing the BYPASS A/Is causes the indicator to go out. The missiles start to spin-up.

SYSTEM MODE:

TRAINING WITH GUID SYS (white)–indicates change of mode selection. This causes mode-controlled, motor-driven switches to assume their required operating positions. All missile mode switches roll to NORMAL. This causes TMPS to initiate the guidance systems spin-up sequence.

STATION REPORTS:

NAV (green)–indicates a nav ready signal has been received from the navigation center.

MC (green)–indicates LCC mode switches roll to TRAINING position. This supplies a simulated MC ready signal to the fire control system.

MTRE MK 6 CHAN 1 and 2 (green)–with selection of this mode, the MTRE Mk 6 power switches on the power distribution panel roll ON. This energizes MTRE Mk 6.

OAG (white)–when the OAG operator applies power to the OAG and selects the local mode of operation, the indicator lights white.

CLOCK AND TIMING:

ERECTION AND TEST TIMING (red)–alarm indication generated in the MCC standby mode is displayed.

COMMAND SLEW:

CHAN 1 and 2 (white)–indicates command slew automatically activated for guidance initialization.

MISSILE MOTION:

MMC1 and MMC2 (green)–indicates the nav data switches have rolled to NORMAL, and both missile motion computers have outputs that are in comparison with each other.

INTERROGATE:

Missiles 1 through 16 (out)–missile-not-normal from the DCC is cleared. This drops the summary interrogate alarm.

HOLD:

Missiles 1 through 16 (red)–alarm indication results from the digital erection assembly timing alarm generated in the MCC standby mode of operation.

CAPTAIN'S PERMISSION TO FIRE (red)–the LCC mode switches roll to TRAINING position which applies the training-hold signal from the attack center panel.

CHAN 1(2) INHIBIT (out); DRISS RESET (out); and HOLD (out)– in this mode, tactical power is applied to DRISS. This causes the alarm condition to drop out.

The supervisor, by depressing the CLOCK AND TIMING/ERECTION AND TEST TIMING A/I, resets the timing alarms at the digital erection assemblies. The A/I lights green and the auto HOLD indicators on missiles 1 through 16 go out.

The supervisor then receives reports from the other battle stations in the fire control system as to manned and ready. These stations include switchboard (SWBD), MTRE Mk 6, MTRE Mk 7, OAG (OPTICS), and the computer (COMP).

Initially, when interrogating a missile, the supervisor should see the following indications:

1. The FC POWER indicator lights green
2. The MISSILE MODE SWITCHES indicator lights green
3. The BATTERY LIFE indicator lights green
4. The TMPS A/I lights yellow
5. The DCC indicator lights green
6. The CA CQO SERVO indicator lights green
7. The MC 1SQ indicator lights green

The GUIDANCE INITIALIZATION, COARSE ALIGN, and ERECTION indicators initially are not lighted, because these functions have not begun.

Approximately 1 minute after the release of the missile manual bypass, the MISSILE REPORTS/TMPS A/I lights green. This indicates that TMPS is in the operate mode. The COARSE ALIGN and ERECTION indicators light yellow. These indicate the presence of missile 800 Hz. The start of the GI sequence is indicated when the GUIDANCE INITIALIZATION indicator lights yellow.

The sequence consists of slewing the outer, middle, and inner gimbals to null (an E-gimbal-null signal is provided by a patch at TMPS) and making a DCC-to-guidance transmission check to verify that the guidance computer is operational. The transmission check consists of a preset echo check, missile motion word transfer, and comparison of the POSEIDON checkout (PCO) word computed by the guidance system. The DCC terminates a successful transmission check by sending a data-check-OK-prepare signal to DRISS. This signal is generated after the missile enters the assign portion of the channel for GI.

If guidance initialization is inhibited, the DCC automatically begins a series of precomputations indicated by the DCC printout PRECOMPS STARTED. Upon the completion of precomputations, indicated by the DCC printout PRECOMPS COMPLETED, the DCC monitors for a gimbal null (P1W1 bit 8). Since no missiles have been through GI, gimbal null has not been achieved. Missile-not-normal is set for all missiles, and bit 11 of the missile/footprint status word is set. The status word can be obtained with the keyboard entry V/N 06001, provided that the POSEIDON command print program (V/N 01009) has previously been entered.

The assignment of missiles to channel for GI is based upon the missile position in the firing order, highest priority first. Missile 1 is assigned to channel 1, and missile 16 is assigned to channel 2. Approximately 1 second after the MCC assign switches roll, gimbals start slewing. A command slew null must be obtained in less than 15 seconds. When the gimbals are nulled, the COMMAND SLEW/CHAN 1 and 2 A/Is light green.

When a missile is assigned to channel for command slewing, the following indications occur:

1. The MISSILE REPORTS/GUIDANCE INITIALIZATION A/I lights red
2. The ASSIGN SWITCHES indicator lights green
3. The ERECTION CHECK indicator lights green
4. The ASSIGN CLEAR A/I goes off
5. The MCC A/D CONVERTERS indicator lights green
6. The MC READY indicator lights yellow
7. The MISSILE NUMBER CHECK indicator lights green
8. The FINE ALIGN SERVOS indicator lights green. (Indicator may be yellow if the servo is not at the null position.)
9. The ALIGN CHECK indicator lights red as a result of a fine align cosine amplifier alarm. The alarm is generated because all MC assign switches do not roll in GI. (Indicator will be yellow if the FINE ALIGN SERVOS indicator is yellow.)

After all missiles have cycled through guidance initialization, the supervisor will disable the circuit by depressing the COMMAND SLEW/CHAN 1 and CHAN 2 A/Is and observe that the indicators go out.

Approximately 25 seconds after completion of GI, the DCC program begins the precomputations for each missile assigned to it. The DCC printer prints PRECOMPS STARTED, and bit 5 of the missile/footprint status word is set. Upon completion, PRECOMPS COMPLETED is printed, and the DCC checks that a gimbal null has been observed for each missile during the GI sequence. If so, precomputations are transferred between the DCCs. Upon the completion of the transfer, PRECOMPS TRAN COMP is printed. This indicates the completion of the guidance initialization and precomputation sequence.

Channel Check.—When directed by the weapons officer (WPNS), and 1SQ is green for any two missiles, the supervisor will initiate channel check.

The supervisor depresses the FIRE MODE MANUAL A/I which lights white and the CHANNEL CHECK A/I which lights yellow. With the selection of channel check, the INITIATE FIRE A/Is light blue, and the CAPTAIN'S PERMISSION TO FIRE indicator goes out. Selection of channel check causes the LCC mode switches to be positioned OFF and the MTRE mode switches to be positioned to TRAINING. Positioning the LCC mode switches causes loss of CAPTAIN'S PERMISSION TO FIRE and STATION REPORTS/MC indications.

Normally, missile 1 and missile 16 will be the first missiles to come to 1SQ, as they are the first to be GI'd because of their positions in the firing order.

The supervisor depresses the INITIATE FIRE A/I for missile 1, and then the INITIATE FIRE /16/A/I. This initiates the channel check sequence. Missile 1 appears in the CHANNEL 1/DENOTE window, and the INITIATE FIRE A/I for missile 1 goes out. The missile priority selected causes the INITIATE FIRE /16/A/I to light blue momentarily until the INITIATE FIRE /16/A/I is depressed. Missile 16 appears in the CHANNEL 2/DENOTE window. At this time, the third missile priority causes the INITIATE FIRE for missile 3 A/I to light blue (provided missile 3 attained 1SQ prior to channel check).

When both missiles have been denoted, the following indications occur in the CHANNEL 1 (2) DENOTE blocks:

1. The DENOTE SWITCH indicator lights green. This indicates that the denote switch for the denoted missile has assumed the commanded position.

2. The DENOTE CLEAR A/I goes out. This indicates that the denote slot is occupied.

3. The ACTION COMPLETE indicator lights yellow. This indicates that the MTRE Mk 6 denote countdown sequence has started but is not yet completed.

Approximately 30 seconds after the first missile has been denoted, the ACTION COMPLETE indicator lights green, momentarily. This indicates that the MTRE Mk 6s have completed the denote sequence timing.

The assign switches are then commanded to roll, with missile 1 assigned to channel 1, and missile 16 assigned to channel 2. The number of the assigned missile is displayed in the CHANNEL 1(2)/ASSIGN window. When the MC assign switches are properly positioned, the denote switches are commanded OFF.

When the missile is assigned for this channel check sequence, the following indications occur on the control console:

1. The DENOTE CLEAR A/I lights green.

2. The DENOTE SWITCH and ACTION COMPLETE indicators go out.

3. The ASSIGN SWITCHES indicator lights green, indicating that all MC and MCC assign switches for the missile number assigned are in their commanded positions.

4. The ERECTION CHECK indicator lights green, indicating that the guidance system gimbals are within 47 ±13 minutes of their commanded position when compared with navigation reference positions.

5. The MMC A/D CONVERTER indicator lights green, indicating that digital missile

motion words displayed at post 034 correspond in magnitude to the analog MMC values being generated.

6. The MC READY indicator lights yellow as a result of the LCC mode switches being in the OFF position.

7. The MISSILE NUMBER CHECK indicator lights green, indicating that the number of the missile that has been assigned has been successfully compared with the number of the missile the DCC is presently computing. (A DRISS sequence, however, is not initiated.)

8. The FINE ALIGN SERVOS indicator lights yellow, indicating that the fine bearing data is not complete and/or the fine align servo has not nulled.

9. The ALIGN CHECK indicator lights yellow, indicating that the cosine detector is normal and the fine align servo has not nulled.

10. The OAG READY channel 1 indicator lights yellow, indicating a simulated next-to-fire signal has been sent to the OAG. This initiates a Bdaim measurement sequence for missile 1.

When the fine align servos null, the FINE ALIGN SERVOS and ALIGN CHECK indicators light green in both channels. At this point, operations in channel 2 stop until channel 1 is cleared. Within 6 seconds of channel assignment, an OAG wedge servo null is obtained. The correct Bdaim signal is available for fine alignment operations in channel 1. With an OAG null, the channel 1 OAG READY indicator lights green. At this time, the fine-align-preparation-complete signal is generated. This causes the missile select switches to roll to the appropriate channel position. The SELECT SWITCHES indicator lights green when the missile select switches have rolled to the commanded position. This completes the fine align loop between fire control and the guidance system. As the fine alignment loop seeks a null, the FINE ALIGN indicator lights yellow.

Within 10 seconds of channel 1 OAG ready, the FINE ALIGN indicator lights green. This indicates completion of the fine align and the channel check sequence for missile 1. Depressing the ASSIGN CLEAR A/I will remove the missile from channel 1 and initiate the fine align sequence for missile 16 in channel 2.

Within 6 seconds of missile 1 resetting, the channel 2 OAG READY indicator lights green. With the OAG sequence completed, the missile 16 select switches are commanded to the CHANNEL 2 position. With the fine align loop completed, the SELECT SWITCHES indicator lights green, and the FINE ALIGN indicator lights yellow, indicating that the fine align process has started. Within 10 seconds of the OAG ready event, the FINE ALIGN indicator lights green. This indicates that fine align null has been obtained. Depressing the channel 2 ASSIGN CLEAR A/I will remove missile 16 from channel 2.

Clearing channel 2 removes all channel 2 indications except:

1. DENOTE CLEAR A/I remains green
2. TIMING A/I remains green
3. POWER indicator remains green
4. ASSIGN CLEAR A/I lights green

The supervisor will then depress the CHANNEL CHECK A/I. By this time, the remaining missiles should be at 1SQ condition (fine erection complete). The CHANNEL CHECK A/I goes out, the CAPTAIN'S PERMISSION TO FIRE indicator lights red, and STATION REPORTS/MC indicator lights green (the LCC mode switches have returned to the NORMAL position), and the INITIATE FIRE/missile 3 A/I goes out. Depressing the FIRE MODE/MANUAL A/I removes the manual fire mode of operation. The indicator goes off, and channel check is complete. The supervisor reports to WPNS: CHANNEL CHECK, BOTH CHANNELS, COMPLETED SATISFACTORILY.

At this point, the fire control system and all ready missiles are prepared for launch.

Firing Sequence.—The supervisor, upon command from the captain on the 1MC to SET CONDITION 1SQ FOR STRATEGIC LAUNCH, selects the TACTICAL mode of operation on the control console. Remember, the fire control system has been in the TRAINING WITH GUIDANCE mode until now.

With the fire control system in the tactical mode, the LCC mode switches and MTRE Mk 6 mode switches roll to the NORMAL (tactical) position. This is the first time they have rolled to this position, and now all tactical subsystems and systems are tied together. Launcher and missile circuits are connected to the fire control system. STATION REPORTS/MC indicator on the control console is green now, indicating that a submerged launch has been selected on the Launcher Control Panels (LCPs).

Since the launcher has not had sufficient time to prepare for launch, an initial hold condition exists on all missiles resulting in the MISSILE REPORTS/MC 1SQ indicator and HOLD for missiles 1 through 16 being lighted red. The CAPTAIN'S PERMISSION TO FIRE indicator is red, because the attack center panel tactical firing switch is in the HOLD position.

As launcher continues to ready the missiles, launcher missile holds are removed, causing removal of auto holds at the fire control console. As missile holds are removed, the HOLD 1 through HOLD 16 A/Is go out, and the MISSILE REPORTS/MC 1SQ indicator lights yellow.

When the OAG operator has completed his operational checkout sequence, he depresses the OPTICAL ALIGNMENT GROUP CONTROL AND DISPLAY LOCAL/MCC A/I and reports OAG in condition 1SQ. The STATION REPORTS/OAG indicator lights green on the fire control console. This indicates that the OAG control has been transferred to the fire control system. With the completion of launcher preparations on the missiles, the MISSILE REPORTS/MC 1SQ indicator lights green, and the 1SQ indicator on the control console should also light green, indicating that the missiles are completely ready for channelized operations and launching.

The supervisor disables COMMAND SLEW in both channels. He then reports to WPNS: FIRE CONTROL IN CONDITION 1SQ FOR STRATEGIC LAUNCH. With the reports that the navigation system, launcher, and fire control are all in condition 1SQ, the weapons officer reports WEAPONS SYSTEM IN CONDITION 1SQ FOR STRATEGIC LAUNCH to the captain. WPNS then directs the supervisor to select WEAPON SYSTEM 1SQ and AUTO FIRE MODE on the control console. Both A/Is light green.

When the Ballast Control Panel (BCP) has reported condition 1SQ, and the hovering system has the ship within the launch attitude, the commanding officer sets the attack center panel tactical fire key to the tactical fire position and announces, YOU HAVE PERMISSION TO FIRE.

The CAPTAIN'S PERMISSION TO FIRE indicator lights green. This initiates the launch sequence. INITIATE FIRE 1 A/I lights blue, momentarily, as missile 1 is denoted in channel 1, followed by INITIATE FIRE 16 lighted blue. With missile 1 denoted, the following indications occur:

1. The missile number is displayed in the DENOTE window.

2. The DENOTE SWITCH indicator lights green, indicating that the denote switch for the denoted missile has rolled to the CHANNEL 1 position.

3. The ACTION COMPLETE indicator lights yellow, indicating that MTRE Mk 6 has started timing the missile denote process at launcher.

4. The DENOTE CLEAR A/I goes out, indicating that the channel 1 denote slot is occupied.

Approximately 30 seconds after missile 1 is denoted in channel 1, the ACTION COMPLETE indicator momentarily lights green, indicating that MTRE Mk 6 has timed out the denote sequence.

With the occurrence of missile number check, the following events occur:

1. The NEXT TO FIRE indicator lights white, enabling the prepare sequence. The signal is sent to the DCC as bit 9 of POSEIDON input word 1 which alerts the DCC of a pending launch sequence.

2. The OAG READY indicator lights yellow, initiating OAG operation (positioning the station pentamirror and obtaining a wedge null).

3. The PREPARE TO FIRE indicator lights yellow. Because the fine align servos have been previously nulled during channel check, a null is rapidly reached. This causes the following events to occur:

a. The FINE ALING SERVOS indicator lights green

b. The ALIGN CHECK indicator lights green, indicating the fine align cosine detector is operating normally

c. The PREPARE TO FIRE indicator lights green, initiating the prepare sequence

Three seconds after missile 1 assignment, the channel 2 DENOTE/ACTION COMPLETE indicator lights green, completing the denote sequence on missile 16.

The assign switches are commanded to roll to the proper channel position, which assigns missile 16 in channel 2. When the MC and MCC switches are properly positioned, the missile 16 denote switches are commanded OFF, causing missile 14 to be denoted. The fifth missile in the firing order, missile 5, is indicated by a blue INITIATE FIRE indication.

When the missile is assigned, the following channel 2 indications occur:

1. The DENOTE window displays missile number 14.

2. The ACTION COMPLETE indicator turns yellow, indicating the start of the denote sequence on missile 14.

3. The ASSIGN readout window displays missile number 16.

4. The ASSIGN SWITCHES indicator lights green, indicating that the MC and MCC assign switches have reached their commanded positions.

5. The ASSIGN CLEAR A/I goes out, indicating a missile has been assigned to the channel (channel 2).

6. The ERECTION CHECK indicator lights green, indicating that the GAMM comparison is within tolerance.

7. The MMC A/D CONVERTERS indicator lights green, indicating that the MCC A/D converters have nulled.

8. The MC READY indicator lights green, indicating that the MC compartment is ready (pressurization and launcher functions are completed).

9. The MISSILE NUMBER CHECK indicator lights green (after a brief delay), indicating that the number of the missile that has been assigned has successfully been compared with the number of the missile the DCC is presently computing.

10. The FINE ALIGN SERVOS indicator lights yellow, indicating that the fine bearing data is not complete and/or the fine align servo has not nulled, and no alignment alarms are present.

11. The ALIGN CHECK indicator lights yellow, indicating that the cosine detector is normal, and the fine align servo has not nulled.

Within 4 seconds of missile 1 assignment to channel 1 (and the presence of fine align servo null), the MC PREPARED indicator lights yellow. This indicates that the prepare-to-fire signal is being sent to the launcher. Shortly after, the MISSILE PREPARED indicator lights yellow, which indicates that the prepare-to-fire signal is being sent to MTRE Mk 6. At this time, DRISS is removed from the reset state, and DRISS activates the DCC for missile and guidance data.

In channel 2, the FINE ALIGN SERVOS and ALIGN CHECK indicators light green. The channel 2 sequence is now halted until missile 1 from channel 1 is launched.

When the channel 1 OAG READY indicator lights green, the select switches are commanded to the proper channel position, and the SELECT SWITCHES indicator on the control console lights green. The fine align process is enabled, and the FINE ALIGN indicator in channel 1 lights yellow.

During this time, the DCC transmits fuze set data to the missile sequencer. When the operation is successfully completed, the DCC sets bit 5 in the POSEIDON output word, causing the FUZE SET indicator to light green.

When the fine alignment process is complete in channel 1, the FINE ALIGN indicator lights green.

The missile prepared operation progresses at MTRE Mk 6 until step 9 of the MTRE sequence. Meanwhile, launcher has initiated the hatch opening sequence when the MC PREPARED indicator lighted yellow. At MTRE Mk 6, operations stop at step 9 until launcher has completed the hatch opening sequence, indicated when the MC PREPARED indicator lights green.

When the MC PREPARED indicator lights green, the final prelaunch operations begin. Fire control removes the power-transfer-inhibit signal from the MTRE, and MTRE Mk 6 picks up the missile prepared countdown and advances to step 10, transferring the missile to internal power. At the completion of this event, MTRE Mk 6 sends the missile-on-internal-power signal to the fire control system. Fire control generates the intent-to-fire-enable signal. This causes the INTENT TO FIRE indicator to light yellow on the control console. At the same time, enable-DRISS transmission is sent to the DCC (bit 10 of POSEIDON input word 1), initiating DRISS transmission to and from the guidance computer.

The DCC-DRISS transmission sequence to the guidance computer consists of the transmission of presets and an echo check, the transmission of missile motion words and an echo check comparison, the receipt of the PCO word and comparison with the DCC computed word, and the issuance of the data-check-OK-fire signal to DRISS. Prior to the missile motion transmission, the DCC sends the disconnect platform command (bit 22 of the POSEIDON output word) to fire control, causing the guidance gimbals to go inertial. With the platform disconnected, the following channel 1 assign indicators go out:

1. ERECTION CHECK
2. ALIGN CHECK
3. FINE ALIGN

Approximately 4 seconds after the missile transfers to internal power, MTRE Mk 6 completes the missile prepared sequence. This causes the MISSILE PREPARED indicator to light green.

About the time missile prepared occurs, the PCO word is received by DRISS and transferred to the DCC for verification. If the PCO word checks out, the DCC generates a data-check-OK-fire signal to DRISS, which, in turn, generates the intent-to-fire signal, causing the INTENT TO FIRE indicator to light yellow.

At this time, the WCO tactical firing switch is closed, completing the conditions required for launch. The fire signal is sent to the launcher. This initiates the missile launch sequence.

With the end of GC echo transmission of missile motion, DRISS generates TO, which starts a 3-second TO maximum timer. The time between data-check-OK-fire signal and the 3-second timeout, less than 3 seconds, establishes a DRISS launch window, indicated by a green INTENT TO FIRE indicator. If the firing switch is not closed during this time, DRISS is recycled, indicated by the INTENT TO FIRE indicator returning to yellow. The DCC-DRISS transmission sequence is repeated with updated data and terminated by a new data-check-OK-fire signal.

When missile-first-motion is detected by launcher, the missile-away signal is sent to fire control. Fire control, in turn, sends the signal to the BCP which controls tube flooding and compensation operations. The missile-away signal is also sent to MTRE Mk 6, causing the MTRE assign sequence to be reset. When MTRE resets, a missile-reset signal is generated in fire control. This causes missile 1, channel 1 assign indications to be cleared except that:

1. The TIMING A/I remains green
2. The POWER indicator remains green
3. The ASSIGN CLEAR A/I lights green

The 1SQ indicator for missile 1 goes out, and the AWAY indicator for missile 1 lights white. The DCC printer prints MSL 01 TO FP YYYY, indicating at which footprint (YYYY) the missile was fired.

As soon as missile 1 is launched, the next-to-fire signal is transferred to channel 2.

The channelized sequence for missile 16, and all following missiles, differs slightly from the first missile. The following indications occur:

1. The NEXT TO FIRE indicator lights white

2. The OAG READY indicator lights yellow

3. The PREPARE TO FIRE indicator lights green, because fine align servo null is already present.

After a 4-second delay, the MC PREPARED indicator lights yellow, which indicates that the prepare signal has been sent to the launcher–starting the hatch opening sequence on missile 16.

Immediately after MC prepared, the MISSILE PREPARED indicator lights yellow, indicating the start of MTRE Mk 6 operation. At this time, DRISS is removed from the reset state and starts communications with the DCC.

When an OAG wedge null is obtained, the OAG READY indicator lights green, the SELECT SWITCHES indicator lights green, and the FINE ALIGN indicator lights yellow.

About this time, the denote sequence is completed on missile 3. The channel 1 DENOTE/ACTION COMPLETE indicator lights green.

In channel 1, missile 3 advances into the assign slot, and missile 5 enters the denote slot. The INITIATE FIRE for missile 5 A/I goes out, and the next missile in the firing order is indicated. The INITIATE FIRE A/I for missile 12 lights blue. With the missile number check, the DCC starts to position the fine align servos and makes an MDF call for the data stored for missile 3.

In channel 2, the FUZE SET indicator lights green when the DCC finishes the fuze setting operation. The FINE ALIGN indicator lights green when the fine alignment loop reaches a null. About this time, the denote sequence is completed on missile 14, causing the DENOTE/ACTION COMPLETE indicator to light green.

MTRE Mk 6 advances to step 9 of the missile prepared sequence and waits for the power-transfer-inhibit signal to be removed by the fire control system. When the hatch opening is completed on missile 16, the MC PREPARED indicator lights green. Fire control removes the MTRE inhibit signal, and MTRE advances to step 10. This transfers the missile to internal power. MTRE sends the missile-on-internal-power signal to fire control, which in turn sends the enable-DRISS-transmission signal to the DCC. Intent-to-fire is generated at the same time, causing the INTENT TO FIRE indicator to light yellow. The DCC-DRISS transmission sequence for missile 16 is initiated.

The DCC-DRISS transmission on sequence to the guidance computer consists of the transmission of presets and an echo check, the transmission of missile-motion words and an echo check comparison, the receipt of the PCO (program checkout) word and comparison with the DCC computed word, and the issuance of the data-check-OK-fire signal to DRISS. Prior to the missile-motion transmission, the DCC sends the disconnect platform command (bit 22 of the POSEIDON output word) to fire control, causing the guidance gimbals to go inertial. With the platform disconnected, the following channel 1 assign indicators go out:

1. ERECTION CHECK
2. ALIGN CHECK
3. FINE ALIGN

When a servo null is reached in channel 1, the FINE ALIGN SERVOS and ALIGN CHECK indicators light green. The missile 3 assign sequence halts until missile 16 is launched from channel 2.

When MTRE completes step 14, the MISSILE PREPARED indicator lights green. Shortly after, the DCC completes the POSEIDON checkout word comparison and issues the data-check-OK-fire signal to DRISS. DRISS in turn generates intent to fire. This causes the INTENT TO FIRE indicator to light yellow. At this time, the WCO firing key is closed, sending the fire request to launcher.

With missile-first-motion, the AWAY indicator for missile 16 lights white, and the

1SQ indicator for this missile goes out. The next-to-fire signal is transferred to channel 1, initiating the fine align, DCC, prepare, and DRISS sequences on missile 3. Missile 14 is assigned to channel 2 to wait its turn to launch. Missile 12 is denoted in channel 2, and INITIATE FIRE for missile 7 lights blue. The remaining missiles alternately cycle between channel 1 and channel 2 based upon the firing order priority originally established.

Upon completion of the launch, the AWAY indicator for each missile is lighted white. The supervisor will set condition 4SQ in the fire control system when directed by the weapons officer. He will then verify that the following documentation has been completed:

1. Results of the countdown in the MCC work log
2. Guidance service logs closed out
3. Missile service logs closed out

This concludes the strategic launch for the fire control system and the fire control supervisor. Now let's take a look at the duties of the other fire control system operators during the SAME strategic launch.

ITOP Operator (ITOP).–Upon the command MAN BATTLE STATIONS MISSILE FOR STRATEGIC LAUNCH, the ITOP operator mans the 35MC announcing system. He usually wears an X43J-2 soundpowered headset for backup communications in event of the 35MC failing, and also to monitor launcher functions.

He makes announcements to the missile compartment on the 35MC in a loud, clear, and deliberate voice, following the precise terminology of the Weapons Operating Procedures.

Generally, these announcements concern channel check, the intended firing order, and other announcements as directed by the WPNS. In monitoring the X43J-2 launcher circuit, he advises the WPNS of problems or casualties at launcher.

When the command to SET CONDITION 1SQ FOR STRATEGIC LAUNCH is made, he announces key events such as WEAPONS SYSTEM IN CONDITION 1SQ FOR STRATEGIC LAUNCH, PERMISSION TO FIRE, the DENOTE, PREPARE, and AWAY status of the missiles. Additionally, he announces any fire control system casualties that might occur. These announcements key the battle station personnel in the missile compartment to any change in the predetermined firing order, or any unusual event or casualty situation, so that they will be ready to respond as soon as possible. This ensures that the strategic launch will continue as smoothly and as rapidly as possible.

MTRE Mk 6 Operator (MTRE 6).–Upon command to man battle stations, the MTRE 6 operator cycles both MTRE 6s in maintenance mode to make sure they are operating properly. He then sets the mode switches to the TRAINING position, after which he assists the COMP (computer operator) with the navigation/fire control transmission checks. These check the integrity and the accuracy of the information between the navigation system and the fire control system and are done via sound-powered phones with an operator in the navigation center. Upon the command to SET CONDITION 1SQ FOR STRATEGIC LAUNCH, the MTRE 6 operator verifies that the mode switches have automatically switched to NORMAL and reports this condition to the fire control supervisor. He then monitors for proper indications and operation during channelized operations. At step 10 of the sequence, he announces that the current missile has transferred to internal power. This alerts the battle station personnel of the status of that missile. He announces any casualty conditions and takes corrective action when directed by the weapons officer or the fire control supervisor.

MTRE Mk 7 Operator (MTRE 7).–The MTRE 7 operator verifies the proper setup of MTRE Mk 7. He installs the MTRE monitor routine canister and ensures that the MTRE Mk 7 is set up for REMOTE operation (controlled by the fire control system). The MTRE 7 operator also verifies that the battery wet life (180 minutes) and load life (60 seconds) timers, on door post 070, are RESET.

Upon command to SET CONDITION 1SQ FOR STRATEGIC LAUNCH, he monitors

MTRE Mk 7 for normal indications and annotates the tube number on the printouts as each missile is channelized. When directed, he reports GO or NO-GO (HI or LO printout) to the WPNS.

DGBC and Fire Control Group Operator (COMP).–This operator, upon manning battle stations, enables ICL transfer in both DCCs. Upon obtaining the time-of-last-change printout from the DCC, he passes it to the WPNS. He then conducts the navigation/fire control transmission checks with the MTRE 6 operator as mentioned above. When the transmission checks are complete and within tolerances, he reports to the supervisor COMPUTER READY. He then assists in the operation of the fire control system, as necessary, and performs any troubleshooting as directed. At the conclusion of the launch, he will disable ICL transfer in the computer.

Optical Alignment Group Operators (OPTICS).–Upon manning battle stations, the OPTICS turns power on to the OAG and verifies that all POWER indicators of the OAG are green. Figure 5-2 (fold-in at the end of chapter) illustrates the OAG display panel proper 1SQ setup.

OPTICS then verifies that all optical tubes between station boxes are lowered and secured in place and that all dust covers are removed from the station boxes and PEACs. He then verifies that the micrometer dials are set to the proper value and that the PEAC table pentamirrors are properly positioned. Reference WEDGE NULL is verified green. He then obtains wedge nulls for all missiles, while the OAG is in the LOCAL mode of operation. After this is accomplished, he gives MCC control of the OAG for the remainder of the countdown. During the countdown, he monitors for proper operation and verifies that the light beam remains unobstructed.

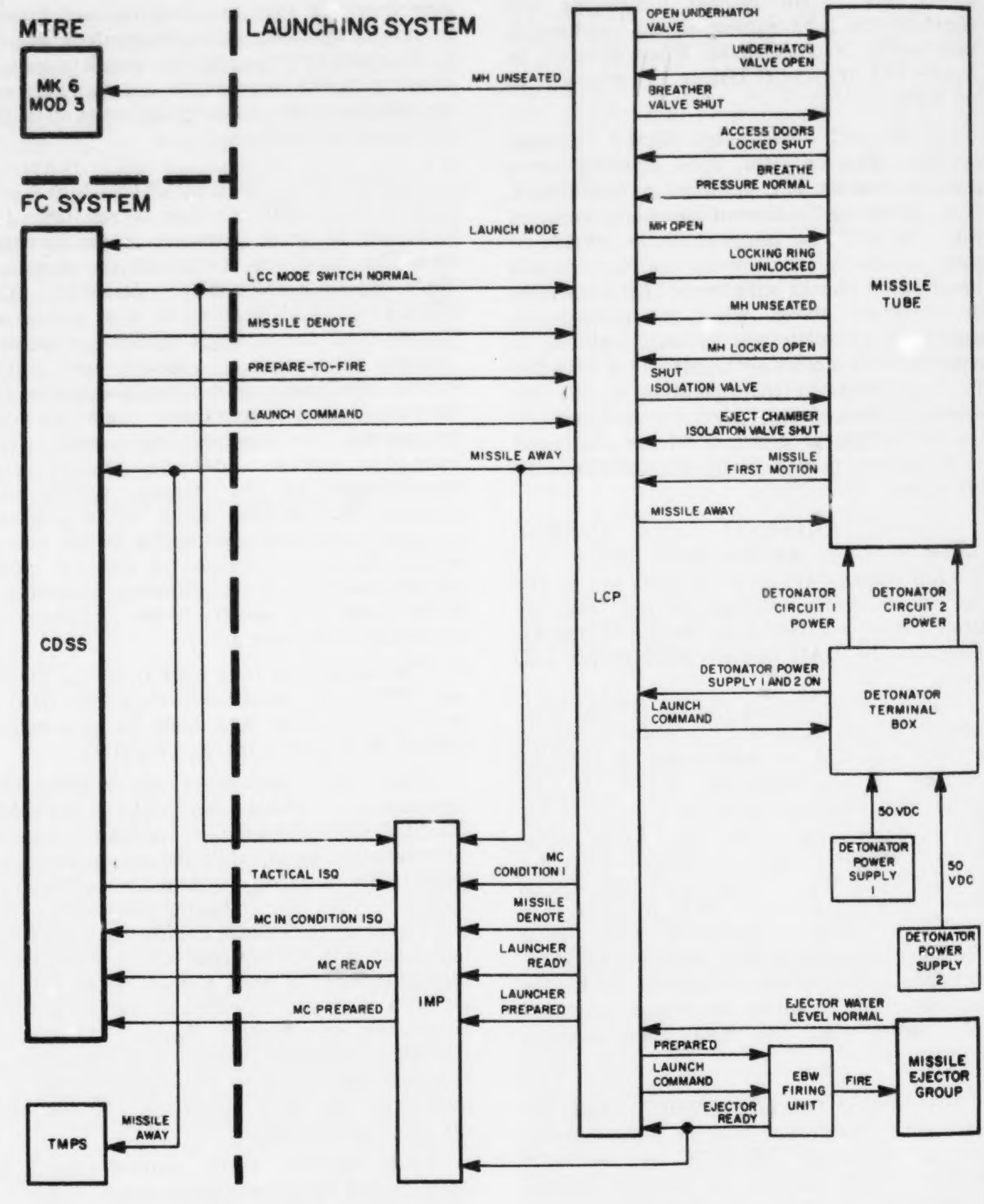
Switchboard Operator (SWBD).–Upon the command to man battle stations, SWBD verifies that all MISSSLE DENOTE and MISSILE ASSIGN toggle switches on the fire control switchboard (located in the middle level, forward in the missile compartment) are in AUTO. He reports this to the fire control supervisor and then monitors the switchboard for normal operation during the strategic launch. In the event of a casualty to a switch or control circuitry to the switches, he can manually roll the switches to the correct positions to allow the countdown to continue.

LAUNCHER PROCEDURES.–Now let's look at this SAME strategic launch from the viewpoint of those operators in the launcher area. The discussion starts with the command MAN BATTLE STATIONS MISSILE FOR STRATEGIC LAUNCH, which is, as you know, the start of the strategic launch procedures. Because the launcher command post is the central coordinating and controlling station for the entire missile compartment, operations must be precise, coordinated, and correct. The launcher station directs the proper pressurization of the missiles, verifies and controls the muzzle hatch opening/closing sequence, arms and controls the ejector group, verifies the proper position of the LCC mode switches, and directs the proper troubleshooting in the event of a casualty to any equipment in the missile compartment.

The upper-level tube team (GDNC – PORT and STBD), the middle-level technician (MSL), and the lower-level tube team MCLL – PORT and STBD) report to the launch station.

When the commanding officer issues the command, "MAN BATTLE STATIONS MISSILE FOR STRATEGIC LAUNCH", a series of events take place, while the remainder of the POSEIDON weapon system is placed in condition 1SQ. The following paragraphs cover the events in the missile compartment that are associated with the launcher system. We will not discuss them in as great a detail as we did the overall actions and functions of the fire control system and its operators. Figure 5-3 illustrates Launcher System Control and Monitoring Interface. Reference to this figure during the discussion will help you to understand the operation more clearly.

Upon manning battle stations, the LCP operator sets the pressurization supply switch to NITROGEN, verifies that the launch mode switch is set to the SUBMERGED position and that the breather valve switches are shut. He sets


MTRE
LAUNCHING SYSTEM
MK 6 MOD 3
MH UNSEATED
FC SYSTEM
CDSS
LAUNCH MODE
LCC MODE SWITCH NORMAL
MISSILE DENOTE
PREPARE-TO-FIRE
LAUNCH COMMAND
MISSILE AWAY
LCP
OPEN UNDERHATCH VALVE
UNDERHATCH VALVE OPEN
BREATHER VALVE SHUT
ACCESS DOORS LOCKED SHUT
BREATHE PRESSURE NORMAL
MH OPEN
LOCKING RING UNLOCKED
MH UNSEATED
MH LOCKED OPEN
SHUT ISOLATION VALVE
EJECT CHAMBER ISOLATION VALVE SHUT
MISSILE FIRST MOTION
MISSILE AWAY
MISSILE TUBE
DETONATOR CIRCUIT 1 POWER
DETONATOR CIRCUIT 2 POWER
DETONATOR POWER SUPPLY 1 AND 2 ON
LAUNCH COMMAND
DETONATOR TERMINAL BOX
50 VDC
DETONATOR POWER SUPPLY 1
50 VDC
DETONATOR POWER SUPPLY 2
IMP
TACTICAL ISQ
MC IN CONDITION ISQ
MC READY
MC PREPARED
MC CONDITION 1
MISSILE DENOTE
LAUNCHER READY
LAUNCHER PREPARED
EJECTOR WATER LEVEL NORMAL
PREPARED
LAUNCH COMMAND
EJECTOR READY
EBW FIRING UNIT
FIRE
MISSILE EJECTOR GROUP
TMPS
MISSILE AWAY

177.119

Figure 5-3.—Launching System Control and Monitoring Interface.

the denote switch to LOCAL and the muzzle hatch switch to REMOTE for the first four tubes to be pressurized. (These tubes are normally 1, 16, 3, and 14, in that order.) The breather valve switches for the first four tubes are then set to the AUTOMATIC position, initiating missile tube pressurization. When missile tube pressure approximately corresponds to sea pressure at the ordered depth, the denote switches are set to the REMOTE position. The procedure is repeated for the remaining tubes, in groups of four, until all tubes are pressurized.

When the commanding officer issues the command to SET CONDITION 1SQ FOR STRATEGIC LAUNCH, the arming crew (MCLL – PORT & STBD TEAMS) manually unlock the EBW firing units on the ejector group. LCP and IMP receive a LAUNCH CONTROL CENTER (LCC) MODE SWITCH NORMAL from the CDSS in the fire control system (when TACTICAL mode is selected on the control console). IMP also receives a tactical 1SQ signal from the CDSS. The LCC-mode-switch-normal signal indicates that the CDSS control circuits (fire control, launcher, and missile) are interfaced with the LCP and IMP control circuits. The tactical 1SQ signal inhibits IMP from generating cruise condition (2SQ) alarms during the launch sequence.

When all of the above conditions have been met, the LCP routes an MC condition 1 signal to IMP. Upon receipt of the MC condition 1 signal, IMP routes an MC in condition 1SQ signal to the fire control system. This indicates that the launching system is ready to proceed with the launch sequence.

The final portion of the launch sequence is initiated when the CO grants permission to fire after the weapon system is at CONDITION 1SQ. The denote sequence is initiated by the fc system when CDSS routes a missile-denote signal to the LCP. The LCP routes the missile-denote signal to IMP to display the number of the denoted missile and removes the breather valve shut command from the missile tube. When the shut command is removed, the breather valve again enters the automatic breathe mode. The missile tube is further pressurized to slightly above sea pressure at launch depth. When this pressure is attained, the missile tube routes a breathe-pressure-normal signal to the LCP, indicating that the missile tube is pressurized.

With breathe pressure normal and the EBW firing unit unlocked, the LCP generates and routes a launcher-ready signal to IMP. IMP then routes an MC ready signal to the CDSS in fire control, indicating that the launching system has completed the denote sequence.

Upon receipt of the prepare-to-fire signal from the CDSS, the LCP initiates the MH opening sequence. The LCP generates and routes an MH open command to the missile tube. The command energizes a locking-ring solenoid control valve that allows the ship's hydraulics to rotate the locking-ring actuators. The actuators rotate the locking ring to mechanically unlock the muzzle hatch. When the locking ring rotates, a locking ring unlocked signal is routed to the LCP, causing the LCP to remove the open underhatch command, and allowing the valve to return to the shut position. This isolates the underhatch area from the pressurization equipment to prevent flooding when the MH is opened. When the locking ring is fully rotated to the unlocked position, a limit switch actuates and routes the MH open command to the MH solenoid control valve. The command energizes the valve and allows the ship's hydraulics to extend the hatch operating cylinder to open the MH. As the MH opens, an MH unseated signal is routed to the LCP. The LCP then routes the MH unseated signal to MTRE Mk 6 to enable transfer of the missile to internal power. When the MH reaches the fully opened position, a limit switch actuates and the MH open command is routed to the locking-pins solenoid control valve. The command energizes the valve and allows the ship's hydraulics to rotate the locking-pins actuator. The actuator extends the pins into sockets in the MH operating gear to mechanically lock the muzzle hatch open. When the locking pins are engaged, a limit switch is actuated, and an MH locked open signal is routed to the LCP, indicating that the MH is open

After the MH is locked open, the LCP operator sets the eject system switch on the LCP to PREPARED, routing a prepared signal to the EBW firing unit and a launcher prepared signal to IMP. The prepared signal causes the capacitors within the EBW firing unit to charge. Upon receipt of the launcher prepared signal, IMP generates and routes an MC prepared signal to CDSS in fire control.

When CDSS receives the MC prepared signal, and all other weapon system functions are complete, a launch command is routed to the LCP. Upon receipt of the launch command, the LCP routes the breather-valve-shut command and a shut-isolation-valve command to the missile tube. It also routes the launch command to the detonator terminal box and the EBW firing unit. The breather-valve-shut command shuts the breather valve to prevent it from flooding after ejection of the missile occurs. The shut-isolation-valve command energizes a solenoid control valve that allows the ship's hydraulics to shut the valve so that steam blow-by is prevented during missile launch. When the valve is fully shut, an eject-changer-isolation-valve-shut signal is routed to the LCP.

Upon receipt of the launch command, the detonator terminal box routes the 50-V d.c. power from the detonator power supplies to the missile tube departure switches as detonator circuit 1 power and detonator circuit 2 power.

Upon receipt of the launch command, the EBW firing unit capacitors discharge. This routes a fire signal to the EBW initiator in the missile ejector group. At ignition of the gas generator, a mixture of gas, steam, and water enters the eject pressure chamber and smoothly ejects the missile.

When the missile lifts off the missile support ring, the departure switches deactivate. The departure switches route detonator circuit 1 and 2 power to the launcher tube closure detonators. The detonators set off the charges to rupture and separate the tube closure and clear the way for the missile passage. The departure switches also route a missile-first-motion signal to the LCP. The LCP then generates and routes a missile-away signal to the missile tube, IMP, CDSS, and to the TMPS.

The missile-away signal to the missile tube causes the solenoid-controlled guidance coolant supply and return cutoff valves to shut. This isolates the missile temperature control system, preventing contamination from seawater. The missile-away signal to IMP inhibits IMP from monitoring an empty missile tube. The missile-away signal to CDSS in fire control enables the fire control system to prepare for the next missile in the firing order. The missile-away signal to TMPS causes TMPS to reset. This removes guidance power from the now empty missile tube.

All of these functions are monitored by the battle stations personnel in the missile compartment. In the event of a casualty or malfunction to any conditions that must occur, the operators are ready to report the problem and take correct troubleshooting action as directed. The reports are made and received by the various personnel in the missile compartment via sound-powered phones, or verbally, depending on their assignments. Strict adherence to WP-184, Strategic Launch Standard Operating Procedure, is vital to the success of operations in the missile compartment as well as in other stations in the POSEIDON weapon system.

CASUALTY OPERATING PROCEDURES (CPs).—To assume that a strategic launch could occur without any malfunctions or casualties in the operation of a system as complex as the POSEIDON weapon system, with its numerous electrical, mechanical, hydraulic, and pneumatic interfaces, is an invitation to failure. To this end, the POSEIDON weapon system has documentation in the form of Casualty Operating Procedures for fire control and launcher personnel to use in the event of any casualty to the system.

Casualty Operating Procedures are designed to accomplish the following objectives:

1. To optimize battle readiness

2. To facilitate missile launch under casualty conditions

3. To prevent casualties from degrading system readiness, reliability, or accuracy

Fire Control CPs.–Fire Control Casualty Operating Procedures have been devised to cover two situations:

1. Those that would normally be expected to occur while the system is proceeding to condition 1SQ.

2. Those that would normally be expected to occur after the missile is channelized.

Each fire control CP is divided into five parts:

1. Weapon System Condition–Point in countdown when casualty is normally expected to occur

2. Indications–Indications that will be noted by the operator when a casualty occurs

3. Immediate Action–Actions necessary to permit uninterrupted launch of the affected missile and/or inhibit system degradation, resulting from compounding of material casualties or personnel error

4. Deferred Action–Diverse actions for ultimate launch of the affected missile. In general, deferred actions will be accomplished after completion of the initial firing sequence, i.e., launch of all ready missiles, except in those instances whereby the casualty can be corrected prior to scheduled entry of the missile into the initial firing sequence. These actions are listed in the preferred order of accomplishment; however, varying situations may dictate out-of-order or partial accomplishment

5. Discussion–Effects of casualty on concurrent or subsequent operations (if any)

You, the fire control technician, should bear in mind that in the event of a casualty to the system, your knowledge of the system and the application of the Casualty Operating Procedures will be called upon. Remember, they are not reserved solely for a strategic launch, but are utilized during Weapons System Readiness Tests as well.

Launcher CPs.–Launcher CPs are designed to accomplish the same objectives we discussed in the fire control CPs. There is, however, one major difference: Launcher Casualty Operating Procedures are intended for emergency use only. Circumstances permitting, every effort must be made to correct the problem by component repair/replacement prior to commencement of launch operations. Additionally, when war reserve missiles are on board, jumpering within the LCPs, IMP, or MTS 2 is prohibited until receipt of a properly authenticated message that releases the war reserve missiles for launch. Jumpering on a tube containing a war reserve missile is also prohibited unless expressly permitted in the applicable CP.

As an FTB, you will eventually have to know some of the major launcher CPs in order to understand the interface problems that could occur between fire control and launcher.

FBM WEAPON SYSTEM LOGS.–These logs are the most important data originated during an upkeep and patrol. The logs reflect valuable crew interpretation and opinion of system performance (especially observed failures) during the upkeep and patrol. Also, Missile Service Log and Guidance Tactical Log data are entered in the FBM Weapon System Logs for later extraction and reduction at a shore facility.

Log Forms.–Five forms are used in completing the FBM Weapon System Logs:

1. The MCC Log form was designed specifically for the MCC logkeeper/watchstander. It reflects tests, results, time of events, remarks, TFRs, and other pertinent information.

2. The MCC Continuation/Subsystem Log form is used as a continuation for the MCC Log form and is the basic logkeeping form for missile and launcher departments.

3. The Pre/Post Patrol Guidance Configuration Summary form is used in the missile compartment and, when completed, comprises part of the Missile Compartment Log.

4. The Pre Patrol Missile Configuration Summary is also used in the missile compartment and is inserted, when completed, as part of the Missile Compartment Log.

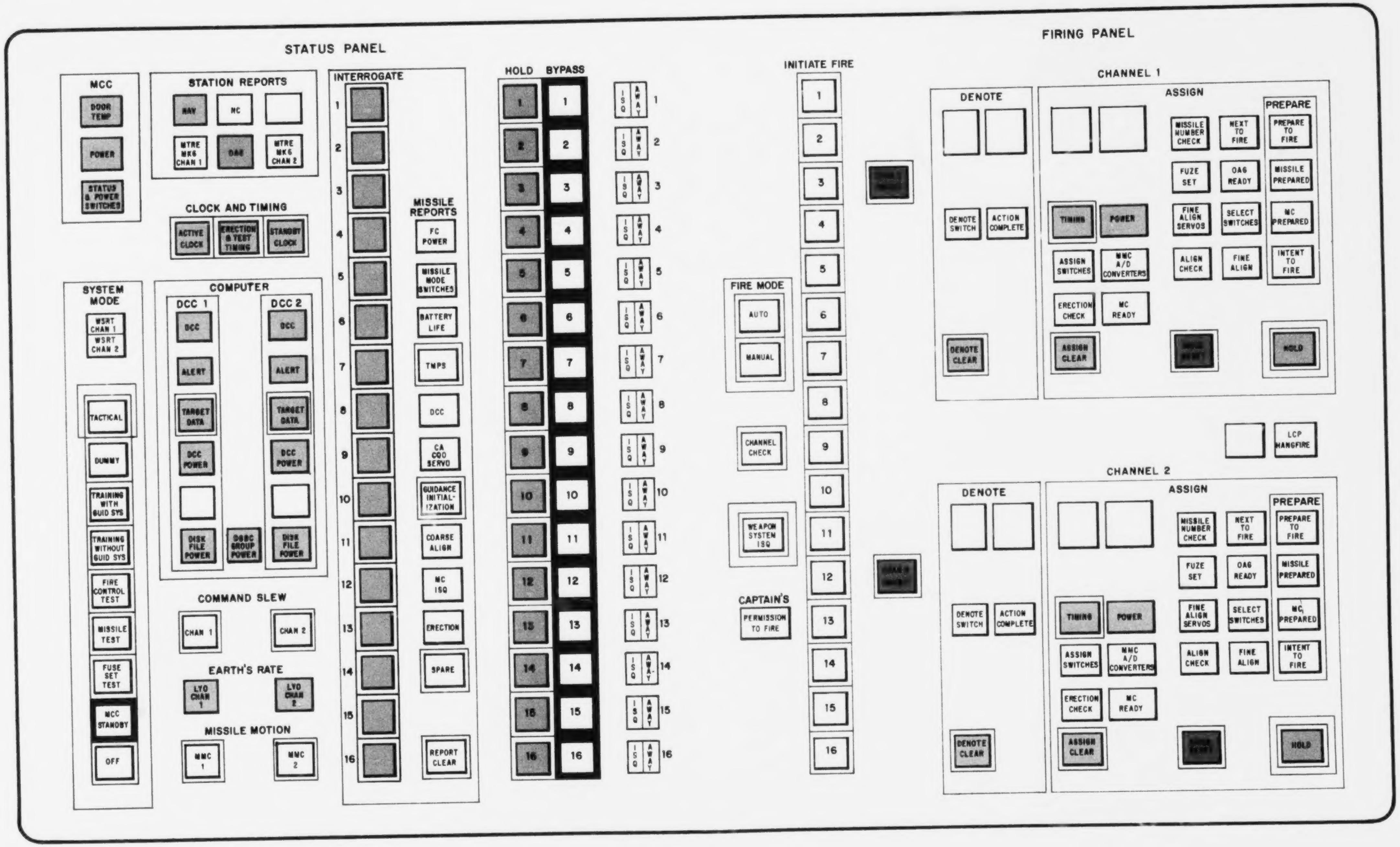
5. The Intermittent Failure Log form is used as an aid in the fault isolation of intermittent missile-related failures. It is specifically designed to aid the technician in the trend detection required. It should be transcribed upon direction of applicable Fault Isolation Procedures (contained in OP 304), or as deemed useful by you, the Fire Control Technician. As forms, they are to be submitted as part of the MCC log.

General Logkeeping Requirements.–Logs should be treated as informal, chronological, real-time records of events as they occur rather than formal, after-the-fact summaries.

Most WPs state the required logging of events that are a result of the actions performed in the WP. Additional information is available in the SSBN Officer's Guide for POSEIDON Weapon System, NAVORD OD 43482, Volume 2.

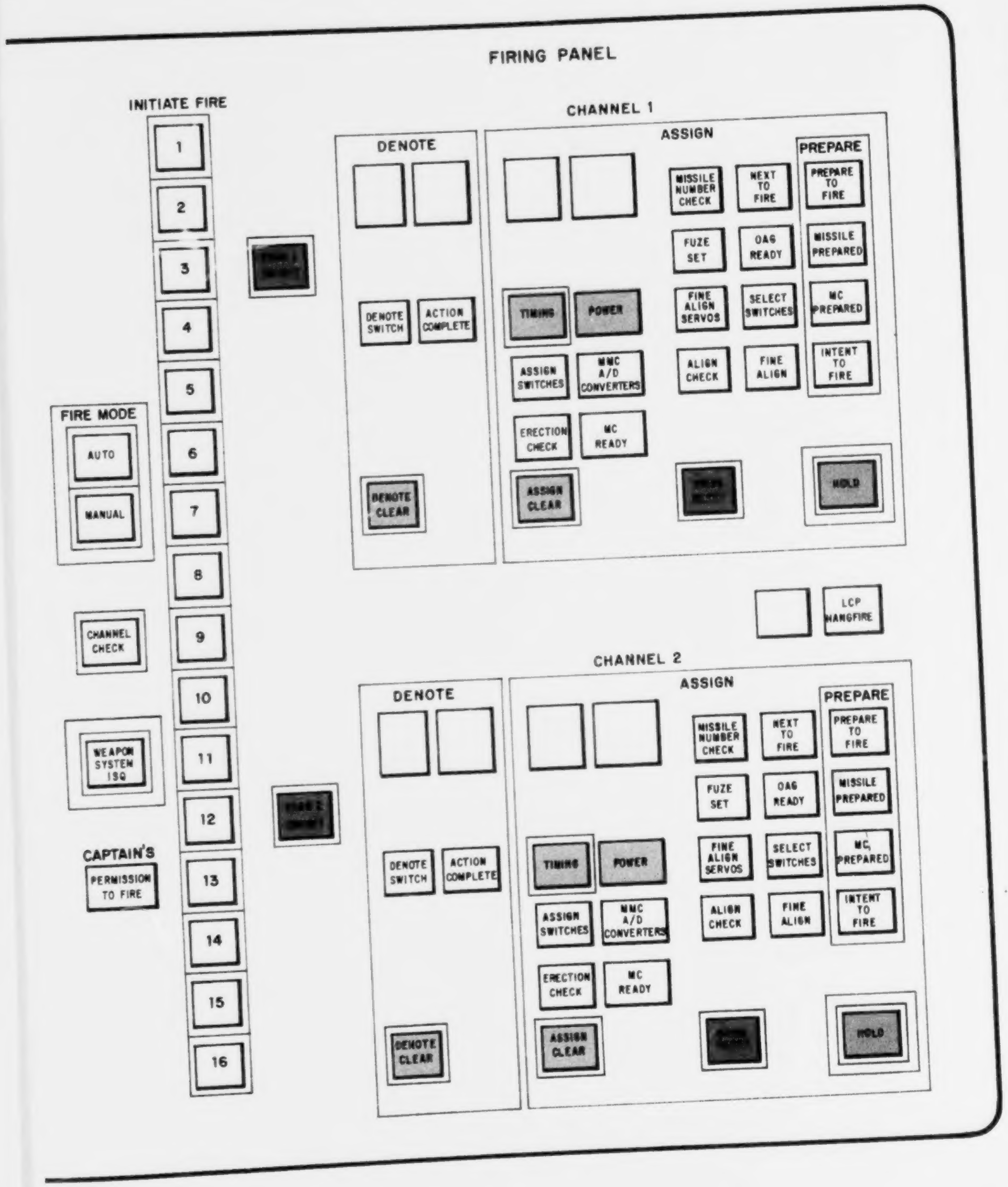
Logkeeping is necessary to maintain the integrity of the POSEIDON weapon system and its related subsystems. Current status of daily PMMPs, SMPs, and other functions and events are readily available in a properly maintained log. Trends toward system or subsystem degradation are easily discerned through proper logkeeping. The fact that FBM submarines are two-crew ships places increased emphasis on logkeeping requirements. Each crew should know what has occurred on the other's patrols and upkeeps. Keeping proper logs will certainly make your job much simpler.

In summary, we have discussed the events that are required to go from 2SQ (normal patrol condition) to 1SQ and launch tactical missiles. At this point you should have a good idea of how the key functions are initiated, how the operators function and their responsibilities, and a basic knowledge of our procedural documentation and the proper use of it. It is important that you know the overall relationship of the operators and the equipment in order to maintain a good working knowledge of the POSEIDON FBM weapon system.


STATUS PANEL
MCC
DOOR TEMP
POWER
STATUS & POWER SWITCHES
STATION REPORTS
NAV
NC
MTRE MK6 CHAN 1
OAG
MTRE MK6 CHAN 2
CLOCK AND TIMING
ACTIVE CLOCK
ERECTION & TEST TIMING
STANDBY CLOCK
SYSTEM MODE
WSRT CHAN 1
WSRT CHAN 2
TACTICAL
DUMMY
TRAINING WITH GUID SYS
TRAINING WITHOUT GUID SYS
FIRE CONTROL TEST
MISSILE TEST
FUSE SET TEST
MCC STANBY
OFF
COMPUTER
DCC 1
DCC 2
DCC
ALERT
TARGET DATA
DCC POWER
DISK FILE POWER
DSBC GROUP POWER
COMMAND SLEW
CHAN 1
CHAN 2
EARTH'S RATE
LYO CHAN 1
LYO CHAN 2
MISSILE MOTION
MMC 1
MMC 2
INTERROGATE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
MISSILE REPORTS
FC POWER
MISSILE MODE SWITCHES
BATTERY LIFE
TMPS
DCC
CA CGO SERVO
GUIDANCE INITIAL-IZATION
COARSE ALIGN
MC ISQ
ERECTION
SPARE
REPORT CLEAR
HOLD
BYPASS
ISQ
AWAY
INITIATE FIRE
FIRE MODE
AUTO
MANUAL
CHANNEL CHECK
WEAPON SYSTEM ISQ
CAPTAIN'S
PERMISSION TO FIRE
FIRING PANEL
CHANNEL 1
CHANNEL 2
DENOTE
DENOTE SWITCH
ACTION COMPLETE
DENOTE CLEAR
ASSIGN
TIMING
POWER
ASSIGN SWITCHES
MMC A/D CONVERTERS
ERECTION CHECK
MC READY
ASSIGN CLEAR
MISSILE NUMBER CHECK
NEXT TO FIRE
FUZE SET
OAG READY
FINE ALIGN SERVOS
SELECT SWITCHES
ALIGN CHECK
FINE ALIGN
PREPARE
PREPARE TO FIRE
MISSILE PREPARED
MC PREPARED
INTENT TO FIRE
HOLD
LCP HANGFIRE

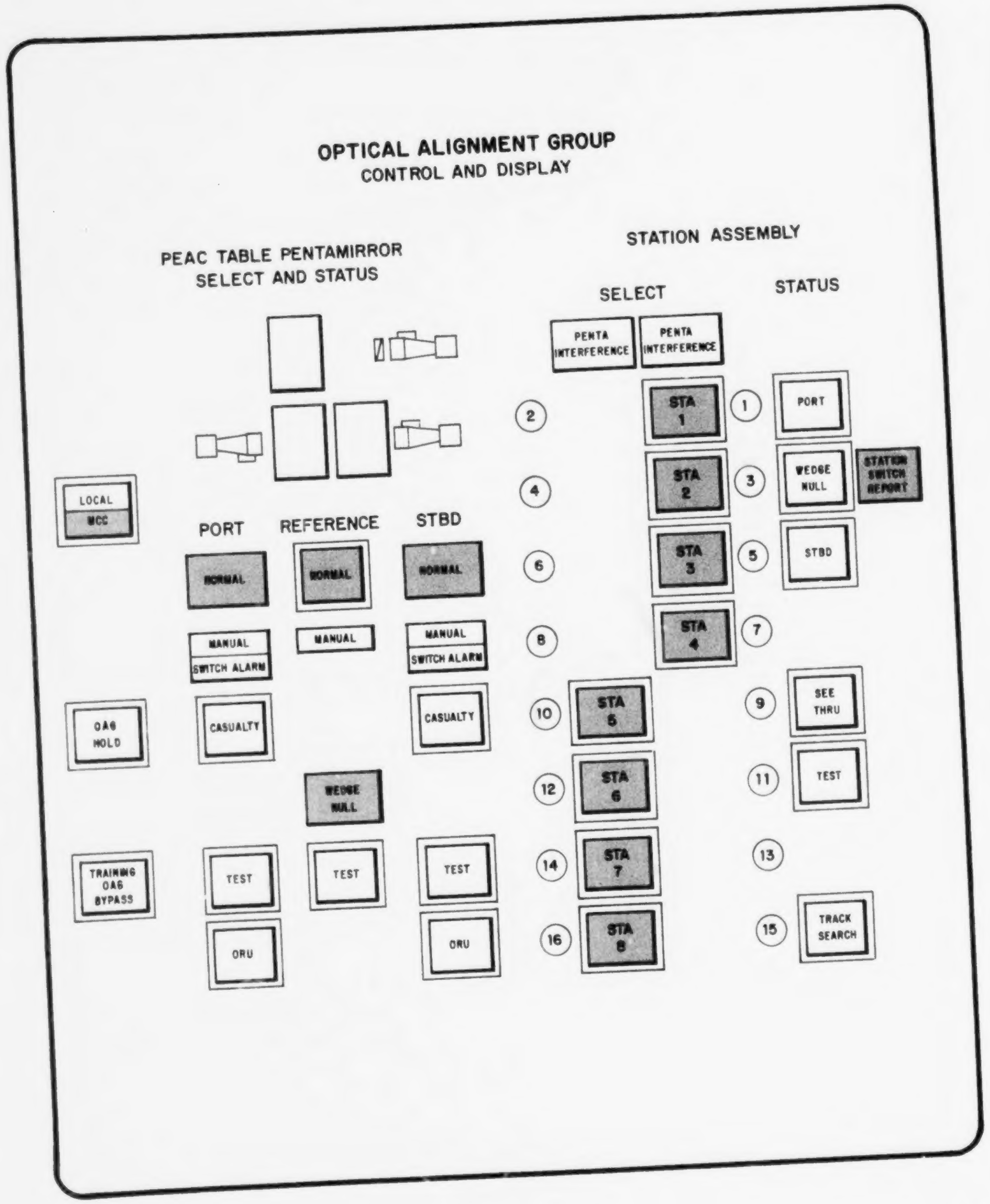
258.15

Figure 5-1.—Fire Control Console, Standby Mode.


FIRING PANEL
INITIATE FIRE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
FIRE MODE
AUTO
MANUAL
CHANNEL CHECK
WEAPON SYSTEM 1SQ
CAPTAIN'S PERMISSION TO FIRE
CHANNEL 1
DENOTE
DENOTE SWITCH
ACTION COMPLETE
DENOTE CLEAR
ASSIGN
TIMING
POWER
ASSIGN SWITCHES
MMC A/D CONVERTERS
ERECTION CHECK
MC READY
ASSIGN CLEAR
MISSILE NUMBER CHECK
NEXT TO FIRE
FUZE SET
OAG READY
FINE ALIGN SERVOS
SELECT SWITCHES
ALIGN CHECK
FINE ALIGN
PREPARE
PREPARE TO FIRE
MISSILE PREPARED
MC PREPARED
INTENT TO FIRE
HOLD
LCP HANGFIRE
CHANNEL 2
DENOTE
DENOTE SWITCH
ACTION COMPLETE
DENOTE CLEAR
ASSIGN
TIMING
POWER
ASSIGN SWITCHES
MMC A/D CONVERTERS
ERECTION CHECK
MC READY
ASSIGN CLEAR
MISSILE NUMBER CHECK
NEXT TO FIRE
FUZE SET
OAG READY
FINE ALIGN SERVOS
SELECT SWITCHES
ALIGN CHECK
FINE ALIGN
PREPARE
PREPARE TO FIRE
MISSILE PREPARED
MC PREPARED
INTENT TO FIRE
HOLD

258.15

Console, Standby Mode.


OPTICAL ALIGNMENT GROUP
CONTROL AND DISPLAY
PEAC TABLE PENTAMIRROR SELECT AND STATUS
LOCAL
MCC
OAG HOLD
TRAINING OAG BYPASS
PORT
REFERENCE
STBD
NORMAL
NORMAL
NORMAL
MANUAL
SWITCH ALARM
MANUAL
MANUAL
SWITCH ALARM
CASUALTY
CASUALTY
WEDGE NULL
TEST
TEST
TEST
ORU
ORU
STATION ASSEMBLY
SELECT
STATUS
PENTA INTERFERENCE
PENTA INTERFERENCE
STA 1
STA 2
STA 3
STA 4
STA 5
STA 6
STA 7
STA 8
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
PORT
WEDGE NULL
STATION SWITCH REPORT
STBD
SEE THRU
TEST
TRACK SEARCH

258.16

Figure 5-2.—Optical Alignment Group Control and Display Panel, 1SQ Condition.

CHAPTER 6

TEST EQUIPMENT AND MAINTENANCE

Equipment maintenance and testing are important in the everyday work of FTBs. You accomplish this part of your work by following procedural documentation in applying the test subsystem (TESS) and various types of test equipment to the problems at hand. (Bear in mind that procedural documentation is also used in other operations within the fire control system). Obviously, proper and safe use of the TESS and test equipment is important.

This chapter is concerned with TESS and its associated interface, and with specific test equipment common to the FTB environment. It also serves as an introduction to the maintenance philosophy that supports the POSEIDON fire control system.

INTRODUCTION TO TESTING

Testing affirms the proper operation of the fire control system and the missiles aboard the FBM submarine. Tests check each subsystem to guarantee operational readiness, and therefore, tactical effectiveness. There are two broad categories of testing, each with a distinct purpose, although these purposes overlap. These categories are missile and guidance system testing, and fire control system testing. These two categories refer to all tests run on the missile and guidance system and on the fire control system, respectively. These tests are run by the FTB operator through the fire control system, mostly initiated from the ITOP. Most of the tests use the DCC to control the test, perform any necessary data reduction, and evaluate the test results. Some of the missile tests are conducted with MTRE Mk 7. However, all the fire control tests are self-contained, that is, run using simulators, test equipment, and maintenance circuits built into the fire control system especially for testing.

Types of Tests

Missile and guidance system tests include ITOP test groups 01 through 06 and 08. Fire control tests include ITOP test groups 21 through 32, fire control printer tests, fuze set tests run from ITOP, and tests on the DCC and its peripheral equipment run from the DCC maintenance panel. Missile and guidance system tests and fire control system tests include both readiness and diagnostic tests.

READINESS TESTS.—Readiness testing exercises all tactical circuits as often as is necessary to determine that the equipment is working properly and can accomplish its mission. Readiness tests are all tests conducted on the missile, guidance system, and fire control system in accordance with a predetermined frequency. Procedures to conduct these tests are included in OP 3751, Standard Maintenance Procedures, and in OD 43144, our Standard Operating Procedures.

DIAGNOSTIC TESTS.—These tests are nonperiodic, normally used only to isolate faulty circuitry after a malfunction has been indicated by failure of a readiness test or by the alarm circuits built into the equipment. Procedures for conducting diagnostic tests are included in volume 5 of OP 3804.

Test Philosophy

The tests make maximum use of automated equipment and the DCC to provide increased accuracy by minimizing the chance of human error, increased speed of testing operations (such as servo positioning), and decreased data reduction time. Reducing the time consumed by tests reduces the time needed to perform preventive maintenance and the time needed to locate casualties, repair casualties, and prove the tactical operability of the fire control system after repairs.

Readiness tests check out a relatively large number of functions and a large amount of equipment and give go or no-go indications. Diagnostic tests, in general, exercise a smaller number of functions and less hardware. If a test fails, they not only give no-go indications but also produce error indications that can be decoded to determine which functions or which hardware may be at fault. Some limits are imposed on diagnostic tests by the automation of testing. Multiple casualties are not checked because of the impossibility of programming to recognize and analyze the thousands of possible symptoms that could be caused by simultaneous faults. Also automatic testing to detect individual type 3 module failures would be extremely complex. Therefore, most diagnostic tests are programmed to detect casualties limited to a small number of type 3 modules.

TESS General Description

TESS is composed of seven individual units:

1. ITOP and test control logic. ITOP enables test equipment selection, test selection and test operation; the test control logic perform test monitoring, test setup, equipment control and switch positioning.
2. Digital Fire Control Test Equipment (DFCTE). This equipment simulates the guidance computer and command sequencer to permit testing of the digital fc subsystems.
3. Simulator Accelerometer (SAA). The SAA provides simulated guidance platform data required to perform erection tests.
4. TMPS tester. The TMPS tester provides power for testing the TMPS test groups and the inflight safety group.
5. Accelerometer Pulse Converter (APC). The APC provides gimbal orientation signals required for GAMET and accelerometer gate tests.
6. Platform servo error oscilloscope. This oscilloscope is used to measure the stable platform gimbal angles.
7. Alignment and erection test milliammeter. This digital milliammeter measures torquer current during alignment and erection tests.

TESS Basic Operation

TESS checks the proper operation of the fire control and missile flight control systems aboard the FBM submarine. TESS confirms that the tactical fc subsystems are operational through the fire control group tests. The missile flight control actuators, the Guidance System Mk 3 gimbal assembly inertial components, and the POSEIDON guidance computer are checked by the missile and guidance group tests.

All test operations are initiated by three SYSTEM MODE actuator/indicators (A/I) on the control console status panel: FIRE CONTROL TEST, MISSILE TEST, AND FUZE SET TEST. Figure 5-1 of the previous chapter illustrates these A/Is. The selection and execution of these tests are controlled from the ITOP portion of the control console by the FTB operator. Power is applied to ITOP when one of these three system mode A/Is is depressed/selected by the operator.

ITOP controls the system switching which sets up the configurations for this selected test. The unit or subsystem under test is connected to the corresponding fire control test equipment (FCTE) or, in the case of the GS test, to the selected missile. The test equipment generates simulated inputs when required, and the outputs of the tested unit are monitored by ITOP and the Fire Control Technician to determine test results.

Programs used in the DCC when tests are conducted perform many functions. When guidance system tests are performed, test routines determine if the measured gimbal assembly parameters correspond with the previously stored calibration values derived at a shore test facility. The DCC test routines also position the gimbal assembly to Byrg values required for ALNSS and ESS tests. Fire control subsystem responses are curve-fitted, or evaluated, on a go or no-go basis from the alignment and erection test milliammeter reading sent to the DCC.

Most of the interfacing between a given DCC and TESS is performed by the Events Translator (ET). The ET sends the test group and test number selected on ITOP to the DCC. The appropriate test routine is selected by ITOPs test executive program as a function of these inputs. Also, the binary equivalent of the alignment and erection test milliammeter reading is read in via the ET relays. The ET also sends the computer-ready signal and test pass or fail signals to the ITOP test-prepared and test-result logic.

The portion of the Mk 88 test equipment used for guidance system calibration and readiness affirmation is located in the gimbal angle controller (GAC) and accelerometer pulse converter (APC) and portions of the alignment and erection subsystems. This equipment orients the gimbal assembly to the positions required for each test. The digital guidance system tests are almost entirely program controlled. The DCC test routines interface through DRISS and the PSC to check the operation of the POSEIDON guidance computer. Missile Test and Readiness Equipment (MTRE) Mk 7 conducts the missile tests (flight control and thrust-vector control systems). Missile tests are operator initiated from ITOP, but controlled by MTRE Mk 7. Test code request (TCR) programs operate in the DCC in support of the missile tests.

FCTE is the hardware used to check the operation of the various Mk 88 subsystems. The FCTE simulates GS and navigation functions, and evaluates the responses of the fc subsystem under test.

The DFCTE provides digital simulation of the POSEIDON guidance computer for digital transmission (DRISS) tests. When fuze set tests are conducted, the missile command sequencer is simulated.

When a subsystem is tested that normally uses inputs from SINS, the FCTE navigation data simulators provide the data. Simulated values permit the subsystem response to be anticipated and evaluated accordingly.

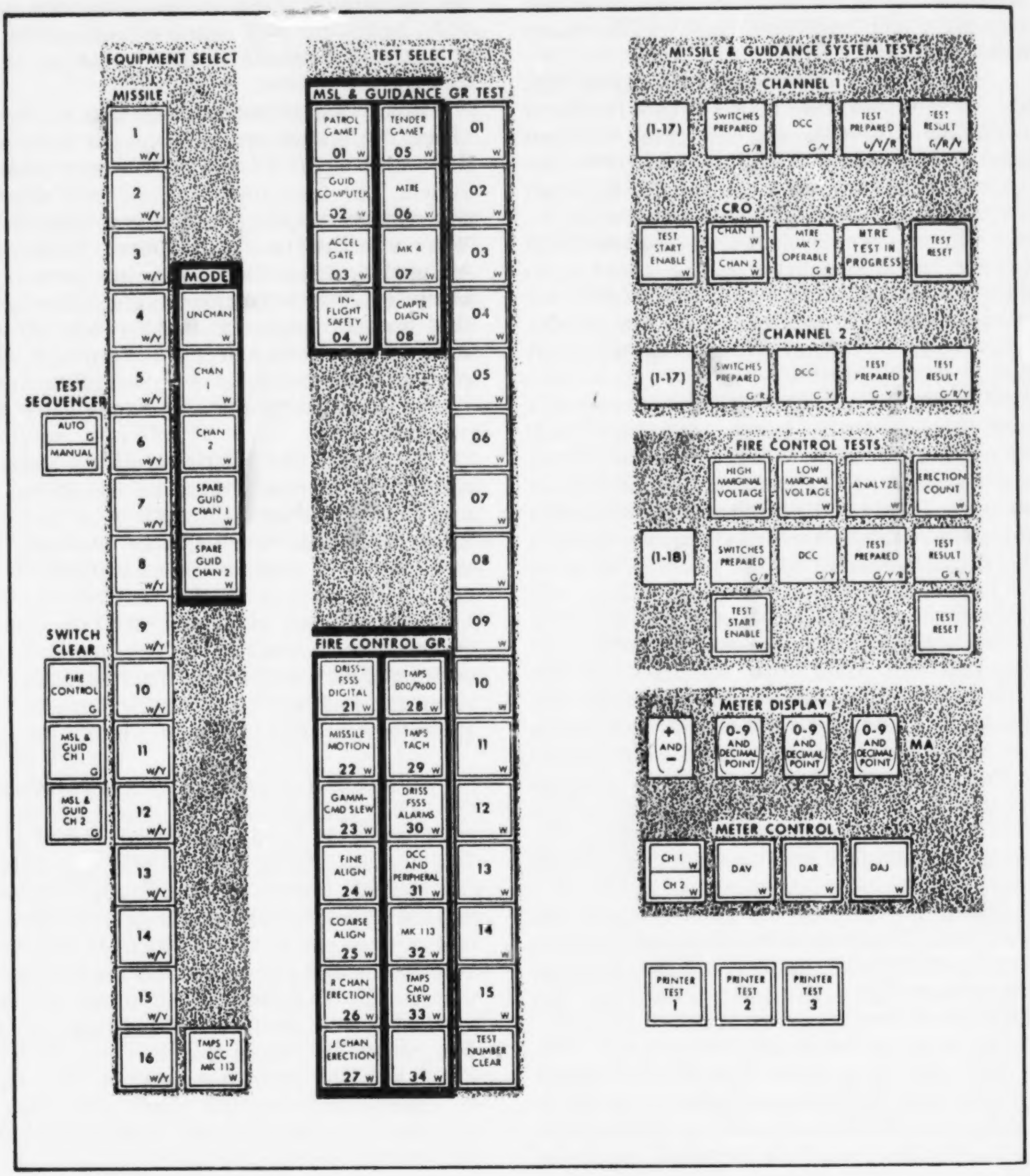
The GS gimbal angle resolvers are simulated by the resolver simulator assembly. Simulated PIPA pulses for ESS tests are generated by the simulator accelerometer (SAA) portion of the DFCTE.

Missile and guidance system tests are used to check the proper operation of the subsystems and components of the missile and guidance system. The tests are performed to certify that the missile subsystems are operating properly. When a malfunction is discovered, certain tests are used as diagnostics to identify parts of the subsystem that are performing improperly. In this manner, a malfunction is isolated to a subsystem or component of the missile. This procedure reduces the down time of the missile system, thus keeping its readiness state at a maximum.

To perform one of the missile and guidance system tests, a missile, channel, test group, and test number are selected at ITOP, as shown in figure 6-1. When both DCCs are available, two missiles may be tested simultaneously except for test groups 04 and 06 (IFS and MTRE). One missile is assigned to fc channel 1; the other is assigned to fc channel 2. The same test is performed on both missiles simultaneously. The automatic fault registration subsystem (AFRSS) generates a separate test result printout for each.

All missile and guidance system tests require the GS gimbals to be orientated to a predetermined position before the tests start. This is accomplished by the CSSS, the ALNSS, and the APC. Once the gimbals are properly positioned, and the DCC and MTRE Mk 7 are ready, a green TEST PREPARED indication informs the ITOP operator that the test can be started. The DCC and MTRE gather the data required for the test and then evaluate the data. The results of the evaluation determine the TEST RESULT indication at ITOP. From this indication and other test result data, such as printouts, the ITOP operator determines the course of action to be followed.

While it is not within the scope of this manual to describe in detail all of the groups of tests, a brief overview of them will be given. Detailed descriptions of each test are available in OP 3804.


EQUIPMENT SELECT
MISSILE
1 W/Y
2 W/Y
3 W/Y
4 W/Y
5 W/Y
6 W/Y
7 W/Y
8 W/Y
9 W/Y
10 W/Y
11 W/Y
12 W/Y
13 W/Y
14 W/Y
15 W/Y
16 W/Y
MODE
UNCHAN W
CHAN 1 W
CHAN 2 W
SPARE GUID CHAN 1 W
SPARE GUID CHAN 2 W
TMPS 17 DCC MK 113 W
TEST SEQUENCER
AUTO G
MANUAL W
SWITCH CLEAR
FIRE CONTROL G
MSL & GUID CH 1 G
MSL & GUID CH 2 G
TEST SELECT
MSL & GUIDANCE GR
TEST
PATROL GAMET 01 W
TENDER GAMET 05 W
GUID COMPUTER 02 W
MTRE 06 W
ACCEL GATE 03 W
MK 4 07 W
IN-FLIGHT SAFETY 04 W
CMPTR DIAGN 08 W
FIRE CONTROL GR.
DRISS-FSSS DIGITAL 21 W
TMPS 800/9600 28 W
MISSILE MOTION 22 W
TMPS TACH 29 W
GAMM-CMD SLEW 23 W
DRISS FSSS ALARMS 30 W
FINE ALIGN 24 W
DCC AND PERIPHERAL 31 W
COARSE ALIGN 25 W
MK 113 32 W
R CHAN ERECTION 26 W
TMPS CMD SLEW 33 W
J CHAN ERECTION 27 W
34 W
01 W
02 W
03 W
04 W
05 W
06 W
07 W
08 W
09 W
10 W
11 W
12 W
13 W
14 W
15 W
TEST NUMBER CLEAR
MISSILE & GUIDANCE SYSTEM TESTS
CHANNEL 1
(1-17)
SWITCHES PREPARED G/R
DCC G/Y
TEST PREPARED G/Y/R
TEST RESULT G/R/Y
CRO
TEST START ENABLE W
CHAN 1 W
CHAN 2 W
MTRE MK 7 OPERABLE G R
MTRE TEST IN PROGRESS
TEST RESET
CHANNEL 2
(1-17)
SWITCHES PREPARED G R
DCC G Y
TEST PREPARED G Y R
TEST RESULT G/R/Y
FIRE CONTROL TESTS
HIGH MARGINAL VOLTAGE W
LOW MARGINAL VOLTAGE W
ANALYZE W
ERECTION COUNT W
(1-18)
SWITCHES PREPARED G/R
DCC G/Y
TEST PREPARED G/Y/R
TEST RESULT G R Y
TEST START ENABLE W
TEST RESET
METER DISPLAY
+ AND −
0-9 AND DECIMAL POINT
0-9 AND DECIMAL POINT
0-9 AND DECIMAL POINT
MA
METER CONTROL
CH 1 W
CH 2 W
DAV W
DAR W
DAJ W
PRINTER TEST 1
PRINTER TEST 2
PRINTER TEST 3

173.503

Figure 6-1.—Integrated Test Operating Panel.

PATROL GAMET, TEST GROUP 01.--Patrol GAMET tests verify the gimbal assembly to determine if the inertial component errors are within predetermined limits originally calculated by a shore-based guidance system test facility. Patrol GAMET is a designation for a group of six tests used to measure the scale factor errors and accelerometer bias of the gimbal assembly. These computed values are compared by the DCC with predetermined system tolerances for go or no-go decisions. The six tests in test group 01 are as follows: sr down test 0101, sr up test 0102, sv down test 0103, sv up test 0104, j down test 0105, and j up test 0106.

The GAMET program is stored on the MDF and is called into DCC core memory by the ITOP test executive whenever any test in group 01 is selected. The results of the patrol GAMET tests are compared with predetermined values which are stored on the MDF. At the end of the test group, the DCC printer prints a summary of patrol GAMET test results. If these tests fail, the gimbal assembly is replaced. When the ship returns to the tender, the guidance system must be recertified. For accelerometer failures, the tender GAMET test group is performed, and the new correction factors are entered through the keyboard. For failures in gyro rates, the GA must be returned to a shore installation for tests and recertification.

GUIDANCE COMPUTER, TEST GROUP 02.–The guidance computer test group consists of five tests which test the guidance system electronics portion, as opposed to the GAMET tests, which verify GA operation. These five tests are main frame test 0201, T0 gate test 0202, SETS test 0203, clock frequency test 0204, and simulated flight test 0205. Before the DCC can execute the guidance computer test program, the DCC performs a braid check of the guidance computer. Failures resulting from a braid check error cause the DCC printer to record a braid check error printout, and the test fail bit sets in POW. If the braid check passes, the DCC reads the test program from the MDF. The tests can be performed individually or sequenced automatically. They may be performed on two missiles simultaneously when both DCCs are available. Test results are indicated at ITOP and are recorded by the control console printer. Test fail messages are printed by the DCC printer.

All digital tests (both fire control and guidance) must be run to completion. If fire control digital tests are not run to completion, resetting the test can cause the ICL to hang up. If guidance computer tests are not run to completion, the guidance computer can hang up, resulting in other guidance computer test failures.

ACCELEROMETER GATE, TEST GROUP 03.–ACCEL GATE is a designation for a group of six tests: sr down test 0301, sr up test 0302, sv down test 0303, sv up test 0304, j down test 0305, and j up test 0306. The accelerometer gate tests check the digital interface between the PIPA electronics and the guidance computer. All tests within test group 03 can be performed in AUTO or MANUAL sequence, depending on the selection at ITOP.

IN-FLIGHT SAFETY, TEST GROUP 04.–In-flight safety (IFS) is a designation for a group of five tests: IFS inhibit (minimum time) test 0401, IFS inhibit (maximum time) test 0402, IFS inhibit threshold test 0403, IFS inhibit (servo error) test 0404, IFS inhibit SETS test 0505. All tests within IFS test group 04 are performed to verify the readiness of the IFS circuits in the guidance system. Because only one TMPS tester exists in the fire control system, in-flight safety tests are conducted on only one missile at a time.

Prior to running the IFS tests, the DCC performs a braid check to ensure that the braid revision of the E/A agrees with the revision number contained in the DCC missile type list for the applicable missile.

TENDER GAMET, TEST GROUP 05.–Tender GAMET test group 05 is a group of 11 tests performed on the guidance system while the submarine is alongside the tender.

The tender GAMET tests cannot be performed without the guidance correction coefficients (GUPELS) tape being entered on the disk to be used while conducting these tests. This tape will enter the correct information, accelerometer drifts, bias, etc., for the guidance system to be tested.

Tender GAMET tests verify the GA with precision sufficiently accurate to recertify the accelerometer and gyro errors. Thus, new correction factors pertaining to accelerometer offsets are calculated during the performance of the tender GAMET tests, and these values are stored on the disk. At the conclusion of the tender GAMET tests, the test results printout are printed by the DCC printer. This printout contains the guidance system test data. The operator then performs a calibration as outlined in the procedural documentation. The results obtained by performing tender GAMET are used for only one calibration. If another calibration is required, another set of tender GAMET tests must be performed.

DRISS AND FSSS TESTS, TEST GROUP 21.–DRISS and FSSS tests 2102 through 2107 are readiness and diagnostic tests selected at ITOP. These tests enter from and are controlled by the ITOP test executive and POSEIDON supervisor (PSUP) programs in the DCC.

Test 2101 verifies the proper operation of the FSSS by using DFCTE and DRISS. Test 2102 verifies correct operation of all circuits in DRISS exercised during a tactical launch sequence. Tests 2103, 2104, and 2105 verify proper operation of the DRISS and POSEIDON ET functions used to perform guidance system tests. Test 2106 is performed to verify the operational readiness of most of the circuits of the PSC and its ability to communicate properly with a DCC. Test 2107 verifies proper operation of the DFCTE.

The first five tests, 2101 through 2105, are normally performed with the sequence in AUTO at ITOP. In this mode, the tests are automatically sequenced until a test pass result is obtained for all five tests or until one of the five tests ends in a fail condition. Any one of these tests may be performed individually if the sequence is placed in MANUAL. Tests 2106 and 2107 are performed with ITOP in a manual sequence mode.

A repetitive cycle option is available to allow all group 21 readiness tests to be repeated for aid in troubleshooting. The operator may cause recycling of each test by depressing the ANALYZE A/I at ITOP after each test has been performed once. When the repetitive cycle option is used, the TEST RESULT indicator at ITOP lights, but no printouts occur.

During the tests, failure data is provided by printouts at the DCC printer. Test pass or fail results are indicated at ITOP and printed by the control console printer.

DRISS and FSSS tests are performed identically by either DCC1 or DCC2 with Channelized DRISS Assembly CDA 1 or CDA 2.

MISSILE MOTION, TEST GROUP 22.–Fire control missile motion test group 22 contains 15 missile motion tests. Tests 2201 through 2204 verify the readiness integrity of the MMCs, the missile motion analog-to-digital (A/D) converters, and the interlace route that the missile motion data follows when transferred to the DCC. Simulated navigation data is supplied to the MMC from self-contained generators. From this simulated data, the missile motion computer computes known values of missile motion as if the missile motion was caused by actual ship motion. If a failure exists, tests 2203 through 2215, which are diagnostic tests, aid in locating faults within the circuitry checked by the readiness tests.

Missile motion tests 2201 through 2215 are initiated at ITOP with the fire control system in the fire control test mode. Tests 2201 through 2214 can be performed manually or sequenced automatically, depending on the test selection at ITOP. Test 2215, which must be selected separately, can only be run on missile 16 and should be conducted only as directed in the troubleshooting procedures in volume 5 of OP 3804. If a test fails, the DCC printer provides a printout of which word or words failed. For tests 2201 and 2202, no DCC printout occurs when all three missile motion words pass. For tests 2203 through 2214, the DCC provides a printout for a test pass. When a fault does occur and tests 2203 through 2214 have all been conducted, the computer evaluates the test values read, and the failure identifier is printed out. Then the operator should refer to the diagnostic procedure in volume 5 for an indication of which modules to replace or directions pertaining to the appropriate manual diagnostic procedures. Depression of the ANALYZE A/I by the operator inhibits the DCC printout and causes the test to recycle. The ANALYZE A/I must be depressed after the first test result is obtained, otherwise the DCC printer will print an analyze request error printout.

Missile motion tests 2201 through 2214 are performed individually for each missile. Tests are functionally identical, regardless of the fire control channel assignment.

GAMM AND CSSS TESTS, TEST GROUP 23.–Test group 23 contains 11 Gimbal Angle Matching Monitor (GAMM) and command slew fire control tests. These readiness tests check the operation of the command slew subsystem (CSSS) null detection circuits and GAMM. All tests in test group 23 may be conducted in either auto or manual test sequence.

FINE ALIGNMENT TESTS, TEST GROUP 24.–Fire control test group 24 contains 13 fine alignment tests numbered 2401 through 2413. Tests 2401 through 2410 are readiness tests that check the circuits in the fine alignment loop of the ALNSS. Tests 2411 through 2413 may be run as either readiness tests or diagnostic tests. As readiness tests, tests 2411 through 2413 verify that the fine Byrg, Lxo, and Lyo servos operate correctly and independently of other online equipment. If a failure occurs during tests 2411 through 2413, the operator may then select the recycle option to cycle the test continuously for troubleshooting or he may elect to use the diagnostic test option.

With automatic sequencing, tests 2401 through 2409 are automatically performed after test selection. Tests 2410 through 2413 must be manually selected. All tests may be individually selected at the option of the operator.

COARSE ALIGNMENT TESTS, TEST GROUP 25.–Fire control test group 25 contains eight coarse alignment tests, numbered 2501 through 2508. Tests 2501 through 2507 are readiness tests that check the performance of the missilized coarse alignment circuits in the ALNSS. Test 2508 may be run as either a readiness test or diagnostic test. As a readiness test, test 2508 verifies that the c(Byrg) servo operates correctly and independently of other online equipment. If a failure occurs during test 2508, the operator may select the recycle option to continuously cycle the test or the diagnostic test option for troubleshooting.

With automatic sequencing, tests 2501 through 2507 are automatically performed after test selection. Each test may be individually selected at the option of the operator. Test 2508 must be individually selected. Test data obtained in test 2503 is stored in the DCC and used in test 2505. Therefore, test 2503 must be performed before test 2505. The test group must not be reset between these tests.

r-CHANNEL ERECTION, TEST GROUP 26.–The r-channel ESS tests, 2601 through 2613, are readiness tests selected at ITOP. These tests enter from and are controlled by the ITOP test executive and POSEIDON supervisor programs in the DCC.

There are two erection test groups, 26 and 27. Test group 26 checks r-channel ESS operation, while test group 27 checks j-channel operation. Except for test 10, each test group contains the same tests. The test group 27 description will not be contained in this write-up because of the similarity.

Test group 26 contains 13 tests that can be performed in an auto or manual test sequence. When the tests are performed in automatic sequence, there is a stop at the end of test 2611. To successfully complete tests 2612 and 2613, which are performed individually, you must refer to the appropriate SMP for the operational sequence.

A repetitive cycle option is available to allow group 26 tests to be repeated as a troubleshooting aid. The operator may cause recycling by depressing the ANALYZE A/I at ITOP after each test is performed once. When the repetitive cycle option is used, the TEST RESULT indicator at ITOP lights, but no printouts occur.

During the running of the tests, failure data is provided by printouts at the DCC printer. For a definition of the printouts, you must refer to volume 5, chapter 35, of OP 3804. For a list of the meter reading range, decimal point location, and polarity of DAr or DAj currents, you must refer to volume 11, table 2-20, of OP 3804. Test pass or fail results are indicated at ITOP and printed by the control console printer.

Erection tests are performed identically by either DCC1 or DCC2 with POSEIDON channel 1 and/or 2 and multiplexer A or B.

TMPS TESTS, TEST GROUP 28.–Fire control test group 28 contains seven TMPS tests. These periodic readiness tests check the TMPS a.c. monitoring circuits, that is, the gimbal angle runaway detector (GARD) servo error monitor and the 9600-Hz power-supply monitor. The tests in test group 28 are under control of the test control logic in TESS. The DCCs are not used during these tests.

To test all TMPS, tests 2801 through 2807 must be performed 17 times, once for each TMPS at the 16 missile stations and once for the TMPS at the spare guidance workbench position. Selection of the automatic test sequence causes tests 2801 through 2807 to be performed sequentially. Manual control allows performance of an individual test.

It should be noted that the above description is for TMPSs that have SPALT 3773 installed. Both the 800-Hz and the 9600-Hz monitors are tests in pre-SPALT 3773 configuration.

TMPS TACHOMETER MONITOR, TEST GROUP 29.–Fire control test group 29 contains 10 TMPS tachometer tests. These periodic readiness tests check the performance of TMPS d.c. monitoring circuits for proper operation. This is accomplished by exercising the tachometer monitor portions of the GARD alarm circuitry. Manual selection of the sequence as well as auto sequencing is available at the ITOP. The tests in group 29 are under control of TESS. The DCCs are not used during these tests.

DRISS AND FUZE SET ALARMS, TEST GROUP 30.–DRISS alarm and timing tests 3001 through 3009 are readiness tests selected at ITOP. These tests enter from and are controlled by the ITOP test executive and PSUP programs in the DCC.

The five DRISS alarm tests, 3001 through 3005, verify the proper operation of various functions by checking the DRISS reset capability. Tests 3006 through 3009 verify proper operation of the timers associated with the DRISS sequence. Tests are performed individually or automatically sequenced. A repetitive cycle option is available to allow group 30 tests, except for tests 3004 and 3007, to be repeated as a troubleshooting aid. This option may be selected after each test is performed once. When the repetitive cycle option is used, the TEST RESULT indicator at ITOP lights, but no printouts occur.

During the conduct of the tests, failure data in the form of error messages are provided by printouts at the DCC printer. Test pass or fail results are indicated at ITOP and printed by the control console printer.

DRISS alarm and timing tests are performed identically by either DCC1 or DCC2 with DRA 1 or DRA 2.

DCC AND PERIPHERAL EQUIPMENT TESTS, TEST GROUP 31.–Test group 31 consists of eight tests. This test group checks the DCCs, POSEIDON ETs, multiplexers, and MDF. All tests in this group are normally selected and performed at ITOP, although some tests require operation at other positions to complete the tests or to select options. Test group 31 contains both readiness and diagnostic tests. The preferred method of performance is in manual sequence because of switching requirements. The individual tests specify necessary equipment configurations.

Tests are performed under control of the PSUP, ITOP executive, and a test program. All test programs are stored on the disk pack in the MDF. Tests are performed identically by either DCC. Where differences are required by the DCC or equipment connected, the program adjusts itself as needed.

This completes our discussion of the major areas of testing with TESS. At this point you should have a basic working knowledge and understanding of TESS, its components, and their relationship with interfaced equipment. Proper maintenance and operation of TESS will assist you in the efficient maintenance of the fire control system and subsystems of the weapon system that may be tested by you.

SAFETY PRECAUTIONS

Accidents are preventable. It is your job to recognize unsafe conditions and see that they are corrected. Observance of safety precautions will help keep your equipment operating, help your career in the Navy, and quite possibly determine whether you survive. "Think safety"! No man is safer than his most careless act.

As a Ballistic Fire Control Technician, at some time in your career, you will either be assigned to duty onboard an FBM submarine or, at a minimum, be assigned to assist in some maintenance or calibration function onboard a submarine. Here, onboard the FBM submarine, safety is perhaps more critical than it might be onboard a surface ship or station because of the very nature of the submarine atmosphere.

To this end, all documentation provided for the operation and maintenance of FBM weapon systems contains warnings and cautions throughout. This includes SMPs, PMMPs, ODs and OPs. However, it should be common sense for you to note safety procedures in other areas not normally your responsibility.

You may possibly consider safety only in the performance of your professional duties. But, as a Fire Control Technician, you will be called on to perform some maintenance or preservation in your assigned spaces onboard a ship or station. Here too, safety is a must.

It is important that you recognize a hazardous condition and take immediate steps to correct it. Safety posters help warn of dangers in working areas or remind personnel to be safety conscious. Warning signs (red) and caution signs (yellow) should be located where hazardous conditions exist. Be aware of areas that are wet or oily or have stumbling hazards. Wear rubber gloves and protective clothing wherever working conditions warrant. Make it a habit to look for and to correct defective tools and equipment.

Handtools

Normally you should have no problems when you work with handtools. In all likelihood, however, you have seen some dangerous practices in the use of handtools that should have been avoided. One unsafe practice involves the use of tools having plastic or wooden handles that are cracked, chipped, splintered, broken, or otherwise unserviceable. Eventually, this practice is sure to result in accidents and personal injuries, such as cuts, bruises, and foreign objects in the eyes. If these unserviceable handtools are not repairable, they should be condemned and replaced.

For basic instructions on the safe use of handtools, consult *Tools and Their Uses,* NAVPERS 10085-B.

Portable Electric Power Tools

Portable power tools should be clean, properly oiled, and in good repair. Before they are used, inspect them to see that they are properly grounded. If a tool is equipped with a 3-prong plug, it should be plugged into a 3-hole electrical receptacle.

Before an extension cord is used to connect a portable electric tool to its power source, plug the extension cord into a dummy (or deenergized) receptacle, and measure the resistance between the housing of the tool and the structure of the ship, using a volt-ohmmeter. The resistance of the grounding conductor must be less than one ohm. Bend and twist the cord while the resistance is measured. A change in resistance indicates broken strands in the grounding conductor. The extension cord must be replaced.

Other safe practices in the use of a portable electric power tool include the following:

(1) Inspect the tool cord and plug before using the tool.

(2) Do not use the tool if its cord is frayed or its plug is damaged or broken. Do not use spliced cables.

(3) Before you use the tool, lay all portable cables so you and others cannot trip over them. Do not use the tool in a damp or wet location.

(4) Connect the tool cord into the extension cord (when required) before inserting the extension into a live receptacle.

(5) When you use the tool, wear equipment that will protect your eyes if there is a chance of particles getting in them. After using the tool, unplug the extension cord (if any) from the live receptacle before unplugging the tool cord from the extension cord. Do not yank the cords.

(6) Stow the tool in its assigned place after you are through using it.

Soldering Irons

In using and handling an electric soldering iron, you can avoid getting burned or shocked by adopting the following practices:

(1) Grasp and hold the iron by its handle. Always assume that the iron is hot, whether plugged in or not. Never use an iron that has a frayed cord or damaged plug.

(2) Hold small pieces to be soldered with pliers or suitable clamps. Never hold the work in your hand.

(3) In resting a heated iron, lay it on a metal surface or its own resting stand. Besides preventing burns, this practice will help prevent fire and equipment damage.

(4) Clean the iron by wiping it across a canvas cloth placed on a suitable surface. Do not hold the cleaning cloth in your hand.

(5) Avoid using too much solder. Use a canvas to wipe away excess solder. Swinging the solder iron to remove excess hot solder could cause a fire in combustible materials or burn the skin and eyes.

(6) Before soldering electronic equipment, you should disconnect it from the power supply. Do not risk coming in contact with RF circuits or high voltages.

(7) After soldering, disconnect the iron from its power supply. Let the iron cool before returning it to its designated storage place.

Test Equipment

Most test equipment is precision and must be handled with care if it is to perform its designed functions accurately.

Some equipment may require special handling; however, there are precautions which apply to test equipment in general. Rough handling, moisture, heat, and dust all affect the useful life of test equipment. Bumping or dropping a test instrument, for example, may destroy the calibration of a meter or short-circuit the elements of an electron tube within the instrument.

The effects of moisture are minimized in electronic test equipment, such as signal generators and oscilloscopes, by built-in heaters. These heaters should always be operated for several minutes before high voltage is applied to the equipment.

Meters are the most delicate parts of test equipment. Protect a meter by making certain that the amplitude of the input signal under test is within the range of the meter. Also, keep a meter as far away as possible from strong magnetic fields.

When servicing a meter, you should disconnect it from the circuit before making resistance or continuity tests. This eliminates the possibility of burning out the meter movement.

GENERAL TEST EQUIPMENT

During your career in the Navy as a Ballistic Fire Control Technician, you will be called on to perform many maintenance and troubleshooting functions. Routine maintenance, particularly during the upkeep of an FBM submarine, requires a good working knowledge of general test equipment such as meters, oscilloscopes, and impedance bridges, as well as some knowledge of special test equipment and special equipment relating primarily to the FBM weapon system. This section will acquaint you with the basic test equipment you are likely to encounter as an FTB.

Again, most procedural documentation that we use in the maintenance and operation of the

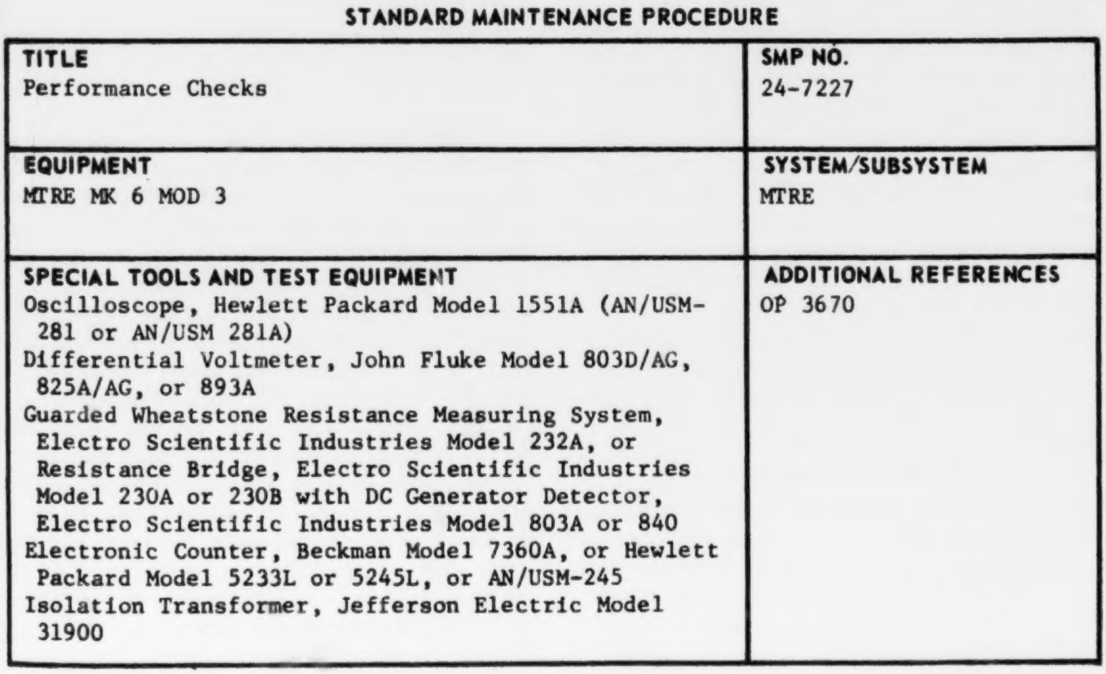
FBM weapon system and the POSEIDON fire control system will list the required items of test equipment and special equipment needed to perform the designated procedures as specified. Some documentation may list alternate equipment. But, here, we will talk about the primary items generally specified in SMPs, PMMPs, and other procedural documentation. Figure 6-2 illustrates the special tools and test equipment required to conduct performance checks on MTRE Mk 6 Mod 3 during SMP #24-7227. This is a good example of specific test equipment being listed in our documentation.

Electrical Meters

The three types of meters that you will most frequently encounter are the ammeter, ohmmeter, and voltmeter. Pay special attention to each of the following applications.

The AMMETER is used to measure current. It must always be placed in series with the circuit to be measured. The ammeter consists of a basic meter movement and a combination of shunt resistors in parallel with it. Either a multiposition switch or a series of pin jacks is used to allow the use of various sizes of shunt resistors to give different current ranges. When you use an ammeter, always have the meter on the highest range before you connect it to a circuit.

The OHMMETER is widely used in making resistance measurements and continuity checks. You will find use for this instrument in checking cables, connectors, and locating faulty components in electrical and electronic circuits. The ohmmeter consists of a basic meter movement connected as an ammeter, a voltage source, and one or more resistors used to adjust the current through the meter movement. The meter movement must be adjusted for "zero



STANDARD MAINTENANCE PROCEDURE

TITLE Performance Checks	**SMP NO.** 24-7227
EQUIPMENT MTRE MK 6 MOD 3	**SYSTEM/SUBSYSTEM** MTRE
SPECIAL TOOLS AND TEST EQUIPMENT Oscilloscope, Hewlett Packard Model 1551A (AN/USM-281 or AN/USM 281A) Differential Voltmeter, John Fluke Model 803D/AG, 825A/AG, or 893A Guarded Wheatstone Resistance Measuring System, Electro Scientific Industries Model 232A, or Resistance Bridge, Electro Scientific Industries Model 230A or 230B with DC Generator Detector, Electro Scientific Industries Model 803A or 840 Electronic Counter, Beckman Model 7360A, or Hewlett Packard Model 5233L or 5245L, or AN/USM-245 Isolation Transformer, Jefferson Electric Model 31900	**ADDITIONAL REFERENCES** OP 3670

258.17

Figure 6-2.—SMP Test Equipment Requirements.

resistance" prior to making resistance measurements. Care must also be exercised not to use an ohmmeter on an energized circuit.

The VOLTMETER utilizes the basic meter movement by placing a high resistance in series with it. The value of this series resistance, called a multiplier, is determined by the current necessary for full-scale deflection of the meter and the voltage being measured. Because the current is directly proportional to the voltage applied, the scale can be calibrated directly in volts for a given, fixed, series resistance.

The sensitivity of voltmeters is given in ohms per volt, and may be determined by dividing the total resistance of movement and multiplier by the full-scale reading in volts. This is the same as saying that the sensitivity is equal to the reciprocal of the current (in amperes). Thus, the sensitivity of a 100-microampere movement is the reciprocal of 0.0001 ampere, or 10,000 ohms per volt. The sensitivity of a given meter movement depends on the strength of the permanent magnet field and the weight of the moving coil and can not be changed.

The sensitivity of a voltmeter is an identification of how accurately it measures voltages in a circuit. In many cases, a sensitivity of 1,000 ohms per volt is satisfactory; however, if the circuit in which the voltage is being measured has high resistance, a greater sensitivity is required for higher accuracy. The higher the sensitivity rating, the higher the resistance in the meter branch of the circuit, and the less the possibility of the meter loading the circuit. If a meter of low sensitivity is used to measure the voltage in a high-resistance circuit, the meter will shunt the load being measured, and an inaccurate reading will result. Thus, the higher the sensitivity, the more accurate the reading.

Like the ammeter and the ohmmeter, the voltmeter normally utilizes several resistors with a switching arrangement to permit multirange operation. The importance of setting the selector switch for maximum voltage range before connecting it to an energized circuit cannot be overemphasized.

In the selection of an a.c. voltmeter, the frequency and waveform of the voltage being measured must be taken into consideration. Some a.c. voltmeters react to the peak value and others to the average (of one alternation) value. Most a.c. voltmeters are calibrated to indicate effective, root-mean-square (rms), values of voltage.

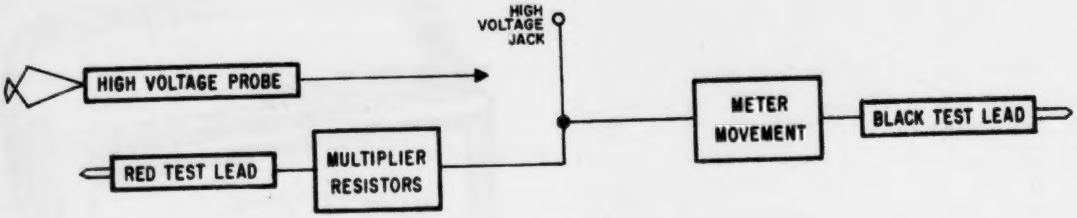
Multimeters

A multimeter is a portable volt-ohm-milliammeter. The complete unit includes test probes which may be used with their probe tips for high-voltage readings. The meter can be used to make d.c. current; d.c. resistance; and d.c., a.c., and output voltage measurements. Most multimeters have an accuracy of between 2 and 5 percent at low frequencies. However, the shunt capacity of the rectifiers used during a.c. measurements reduces the meter accuracy as the frequency of the voltage being measured increases. When the voltage under test is above audio frequency, an electronic multimeter or a.c. vacuum-tube voltmeter should be used.

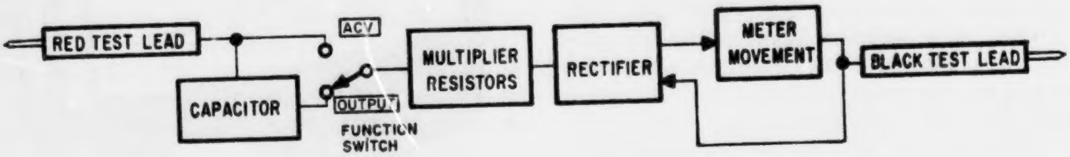
OPERATION.–The following discussion and the associated block diagrams treat the circuits within the meter as they are arranged to measure voltage, current, or resistance.

D.C. Voltmeter Circuit.–The block diagram of the meter circuit that is used for measuring d.c. voltages is shown in figure 6-3A. The circuit is selected by the function switch and the range switch, neither of which are shown. The function switch connects the meter movement for d.c. voltage operation, and the range switch selects the value of the resistors within the meter that are in series with the meter movement for voltages up through 500 volts. For higher d.c. voltages, special test jacks on the meter and special test probes are used; the range switch and the multiplier resistors are not in the circuit. The high-voltage jack and probe place their resistance in series with the meter movement. For any range, the total resistance in series with the meter movement will regulate the meter current to provide a proportional current to indicate the amount of voltage in the circuit.

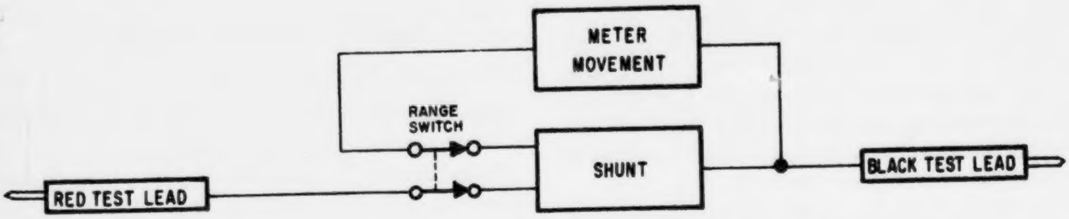
A.C. and Output Voltage Circuits.–The circuits that measure a.c. and output voltages (fig. 6-3B) are selected by the ACV and


HIGH VOLTAGE JACK
HIGH VOLTAGE PROBE
METER MOVEMENT
BLACK TEST LEAD
RED TEST LEAD
MULTIPLIER RESISTORS

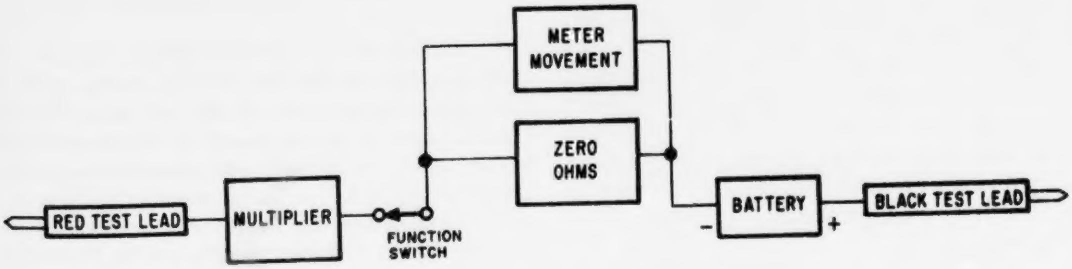
Ⓐ FUNCTIONAL BLOCK DIAGRAM OF DC VOLTAGE CIRCUITS


RED TEST LEAD
ACV
CAPACITOR
OUTPUT
FUNCTION SWITCH
MULTIPLIER RESISTORS
RECTIFIER
METER MOVEMENT
BLACK TEST LEAD

Ⓑ FUNCTIONAL BLOCK DIAGRAM OF AC & OUTPUT VOLTAGE CIRCUITS


METER MOVEMENT
RANGE SWITCH
SHUNT
BLACK TEST LEAD
RED TEST LEAD

Ⓒ FUNCTIONAL BLOCK DIAGRAM OF DC CURRENT CIRCUITS


METER MOVEMENT
ZERO OHMS
RED TEST LEAD
MULTIPLIER
FUNCTION SWITCH
BATTERY
−
+
BLACK TEST LEAD

Ⓓ FUNCTIONAL BLOCK DIAGRAM OF OHMMETER CIRCUITS

1.311.314

Figure 6-3.—Functional Block Diagram of Multimeter.

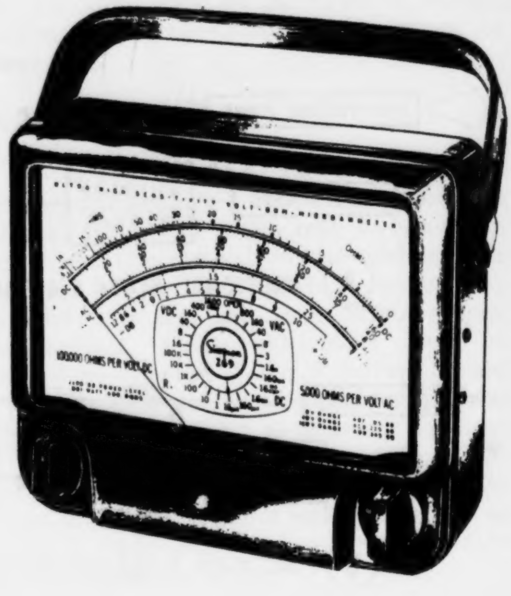
OUTPUT positions of the function switch. For voltages up through 500 volts, a range is selected with the range switch, not shown. For the 1000-volt range, the red test lead connects into the special 1000-volt a.c. jack. This removes the range switch and the regular multipliers from the circuit. The a.c. voltage being measured is impressed across the circuit between the red and black test leads. But the rectifier allows current flow in only one direction through the meter movement. The meter is calibrated to indicate the rms value of the a.c. voltage applied to the instrument circuit.

D.C. Current Circuits.—The circuit that measures d.c. current (fig. 6-3C) is selected with the DC μA MA AMPS position of the function switch, not shown. For currents up to 1000 milliamperes, the range is selected with the range switch. For the 10-ampere range, the red test lead connects into the special 10-AMPS jack. The range switch and regular shunts are removed from the circuit. Each range provides a parallel (shunt) resistance for the meter movement, and the circuit current divides between these two parallel paths. Shunts are designed to be extremely low resistance in comparison with the resistance of the meter movement. Therefore, the large percentage of current goes through the shunt (low resistance path). The proportional part that passes through the meter movement indicates the total circuit current.

Ohmmeter Circuits.—The ohmmeter circuit (fig. 6-3D) and its ranges are selected with the function switch. An internal battery furnishes the power for all resistance measurements. For each range, the circuit is arranged so the meter will indicate zero ohms (full-scale deflection) whenever the red and black test leads are shorted together. When you connect a resistance between the test leads, this resistance will be in series with the instrument circuit, and less current will flow through the meter movement. The amount of reduced meter deflection indicates how much resistance is between the test leads.

Multimeter AN/USM-123

The Multimeter AN/USM-123 (fig. 6-4) is a highly sensitive meter that can be used in most maintenance tasks performed on fc equipment. The meter is also referred to by the manufacturer's designation as the Simpson Model 269. All function and range settings are made with the range selector switch in the lower right-hand corner of the meter. The other knob on the meter is the zero ohms control which is used to adjust the meter indicator before d.c. resistance measurements are made.



4.133

Figure 6-4.—Multimeter, AN/USM-123.

GENERAL OPERATION.—Before you make any measurements or tests with the multimeter, set the pointer to zero. Turn the screw below the center of the meter scale until the pointer is exactly over the zero mark on the scale.

Test leads and test lead jacks are color coded. It is a good idea to get in the habit of matching the colors; that is, red lead to red jack, etc. Red is then positive (POS), and black is negative (COM). Using the color code will not affect meter accuracy but may help you in making d.c. measurements where proper polarity is required to produce pointer deflection in the right direction.

When you use the multimeter as either an ammeter or voltmeter, turn off all power to the circuit under test, connect the meter leads, and then turn on the power to take the reading. Turn off the power before disconnecting the leads. When high voltage is checked, use extreme care.

D.C. Voltage Measurements.–To protect the meter always start with a high setting and work down to the proper setting of the range indicator. Connect the probe end of the black test lead to the negative side of the circuit to be tested, and the probe end of the red test lead to the positive side. Turn on the power to the circuit to be tested. If the pointer deflects to the left of zero, the leads are reversed. Turn off the circuit power, reverse the leads, and retest.

If the voltage in the circuit is above 1,600, set the range point to the 1600-4000-volt d.c. position. Screw the high-voltage probe extension over the red test probe if a high positive voltage is to be measured, or over the black test probe if a high negative voltage is to be measured. Read the voltage using the 0 to 40 scale and multiply the reading by 100.

A.C. Voltage Measurements.–Rotate the range selector switch until the range pointer indicates an appropriate a.c. voltage range. Connect the test probes across the circuit to be tested. A.c. voltages will read correctly regardless of the polarity of the test lead connections. Turn the power on in the circuit, and take the measurement.

Output Measurements.–If there is a mixture of a.c. and d.c. voltage in the circuit under test, only the a.c. voltage is measured when the meter is connected for output measurements. The d.c. component is blocked. Rotate the range selector switch to the appropriate a.c. voltage range. The red lead should be in the jack marked OUTPUT located on the left side of the meter. Connect the test probes across the voltage to be measured. Turn on the power to the circuit and read the appropriate VAC scale.

D.C. Current Measurements.–To take d.c. current measurements from 0 to 1.6 amperes, rotate the range selector switch to the appropriate d.c. range. Open the circuit to be tested and connect the meter in series with the circuit. Connect the red test probe toward the positive side, and the black probe toward the negative side of the open circuit. Turn on the power to the circuit and read the current on the black arc marked d.c. If the pointer is deflected to the left of the scale, the test probes are reversed.

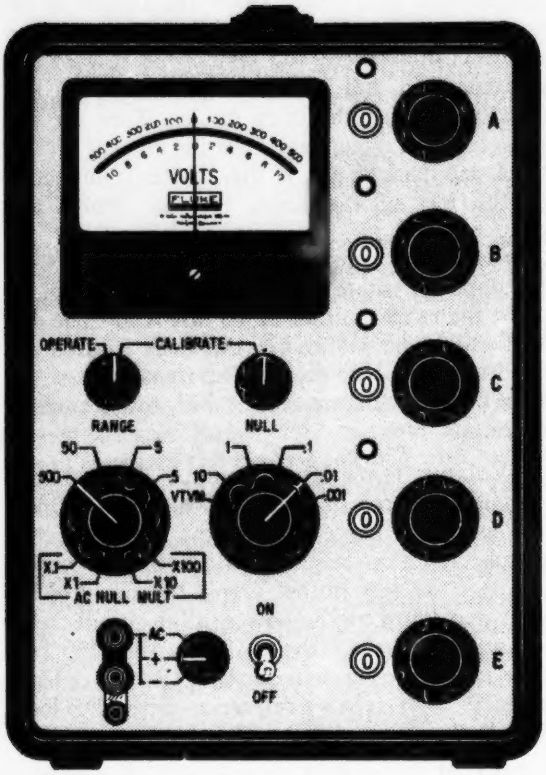
To take d.c. current measurements from 0 to 16 amperes, rotate the range selector switch to place the range pointer at 16 MA-AMP. The red lead should be in the 16-AMP jack located on the left side of the meter. The remainder of the procedure is the same as for taking lower current readings.

Volume Level Measurements.–The volume level is measured in decibels, which are defined in *Basic Electronics.* Rotate the range selector switch to the required a.c. voltage range. Connect the test probes across the signal to be measured. Turn on the power in the circuit to be measured and read the scale marked dB. The scale is based on a zero decibel (dB) power level of 0.001 watt across a reference impedance load of 600 ohms.

D.C. Resistance Measurements.–Rotate the range selector switch to the desired position. Short the test probes together and rotate the ZERO OHMS knob to set the pointer to indicate zero ohms at the right-hand end of the dial. Separate the test probes and connect them across the resistance or the portion of the circuit that is to be measured. Read the value indicated on the OHMS arc at the top of the dial. Never leave the selector switch in one of the "ohms" positions after your last measurement. Inadvertent shorting of the leads could cause the battery to be discharged.

Differential Voltmeter

The differential voltmeter is a reliable, precision item of test equipment. Its general function is to compare an unknown voltage with an internal reference voltage, and to indicate the difference in their values. The differential voltmeter in most common use is the 803D/AG (fig. 6-5), manufactured by the John Fluke Co.



124.375
Figure 6-5.—Differential Voltmeter, Model 803 D/AG.

The 803D/AG is usable as an electronic voltmeter, as a precision potentiometer, and as a megohmmeter. It can also be used to measure the execursions of a voltage about a reference value. Ease of operation, inherent protection from any accidental overload, and high reliability of readings are additional advantages of the instrument. It is accurate enough for precision work in calibration laboratories, yet rugged enough for general shop use.

The heart of the unit is a precision 500-volt d.c. reference power supply. This 500 volts can be precisely divided into increments as small as 10 microvolts by means of 5 voltage dials. Unknown a.c. or d.c. voltages are matched against the precise internal voltage until no deflection occurs on the panel meter. The unknown voltage is then simply read from the voltage dials. In the highest null sensitivity range, a potential difference between unknown and reference voltages as small as 0.01 volt causes full-scale meter deflection.

At null, the differential voltmeter presents an "infinite" input impedance to the voltage under measurement, almost completely eliminating circuit loading.

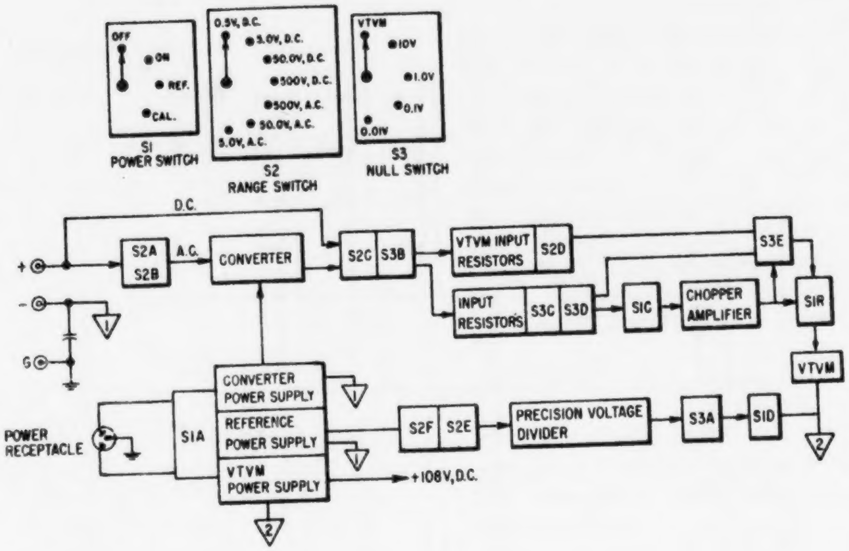
A functional schematic diagram of the differential voltmeter is shown in figure 6-6. The principal circuit divisions are as follows:

1. A 500-volt d.c. reference power supply
2. Precision voltage divider network
3. VTVM
4. Chopper-amplifier
5. Converter and converter power supply

The system circuitry is designed with two separate common returns. One of these, the return for the converter power supply and reference power supply, provides a safety factor for personnel and a capability for measuriing a potential difference between two voltages. The other, which is the common return of the VTVM power supply, is connected to the known reference voltage output from the precision voltage divider network. This arrangement provides a constant d.c. voltage of +108 volts across the differential amplifier regardless of the d.c. potential applied to the grid.

D.C. REFERENCE POWER SUPPLY.—A fullwave rectifier with its associated filter network supplies a d.c. voltage of approximately 1,000 volts to a conventional electron controlled voltage regulator. The regulated output is maintained at 500 volts, ±0.01 percent.

In the 500-volt d.c. position, the RANGE switch (S2E) passes this 500 volts directly to the precision voltage divider. In the 50-volt, 5-volt, and 0.5-volt d.c. positions, range resistors controlled by S2F divide the reference voltage to 50, 5, and 0.5 volts d.c., respectively. In all a.c. positions of the RANGE switch, only 5 volts of the reference supply is used, because the maximum output of the a.c. to d.c. converter is 5 volts.


OFF
ON
REF.
CAL.
S1
POWER SWITCH
0.5V, D.C.
5.0V, D.C.
50.0V, D.C.
500V, D.C.
500V, A.C.
50.0V, A.C.
5.0V, A.C.
S2
RANGE SWITCH
VTVM
10V
1.0V
0.1V
0.01V
S3
NULL SWITCH
D.C.
+
-
G
S2A
S2B
A.C.
CONVERTER
S2C
S3B
VTVM INPUT RESISTORS
S2D
S3E
INPUT RESISTORS
S3C
S3D
S1C
CHOPPER AMPLIFIER
S1R
VTVM
CONVERTER POWER SUPPLY
REFERENCE POWER SUPPLY
VTVM POWER SUPPLY
POWER RECEPTACLE
S1A
S2F
S2E
PRECISION VOLTAGE DIVIDER
S3A
S1D
+108V, D.C.
1
2

124.376

Figure 6-6.—Differential Voltmeter, Functional Schematic Diagram.

PRECISION VOLTAGE DIVIDER.—Each of the four precision voltages available from the reference supply must be made adjustable through a precision divider string so that unknown voltages may be nulled or matched exactly. The five decade resistor strings (fig. 6-7) accomplish this function.

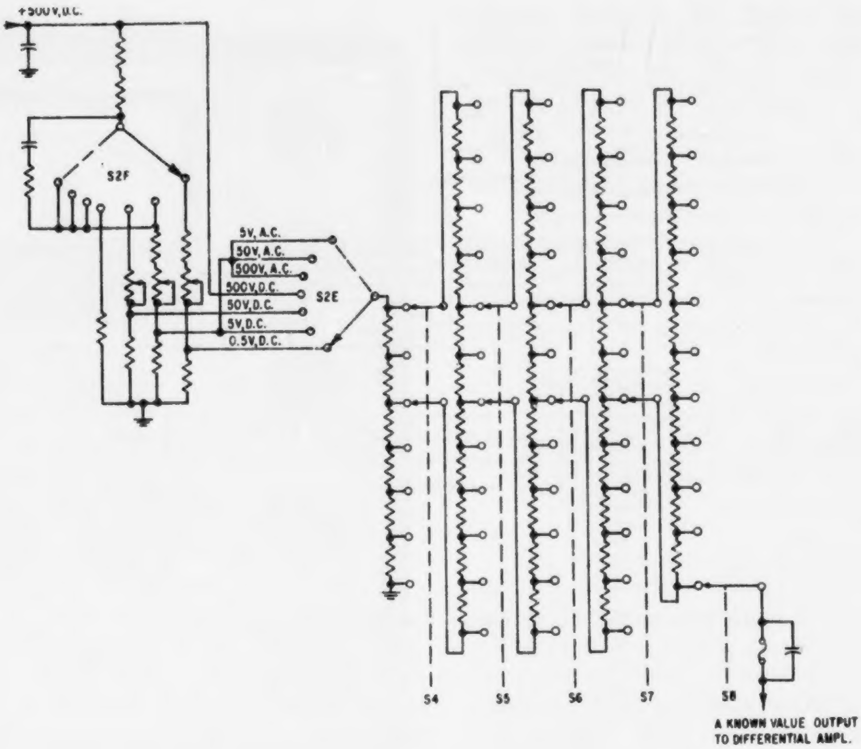
Note that each string, with the exception of the first, parallels two resistors of the string that precedes it. Between the two wipers of S4, there is a total resistance of 40K and a total voltage of 100 volts d.c. with the range switch in the 500-volt d.c. position. Across the wipers of S5, S6, and S7, there are 10, 1, and 0.1 volts d.c., respectively. Switch S8 selects an increment of 0.01 volt d.c. from the last decade. These voltages are reduced by a factor of 10 for each successively lower voltage range.

All resistors of each decade are matched, and all decades are matched for each instrument, providing an overall divider accuracy of 0.005 percent.

With the NULL switch in any null range, the output of the precision voltage divider appears at the grid (fig. 6-8) of one-half of the VTVM differential amplifier. A one/two-hundredths ampere (5 milliampere) fuse protects this output.

VACUUM-TUBE VOLTMETER.—When the meter is in the differential mode, output voltage from the precision voltage divider appears on the grid of V4B, one-half of the differential amplifier (fig. 6-8). The unknown voltage appears on the grid of V4A, the other half of the differential amplifier. Any difference between these potentials is indicated by the meter coupled between the cathodes of V4A and V4B. When the output voltage exactly matches the unknown, the meter reads zero and no current is drawn from the source being measured, because the same potential exists on both sides of the input resistances.

When the meter is used as a conventional VTVM, the grid of V4B is connected to the 0-volt bus, or negative binding post. With the range switch in the 0.5-volt d.c. position, the unknown voltage appears directly on the grid of



124.377

Figure 6-7.—Precision Voltage Divider.

V4A, and the meter indicates the approximate value of the unknown voltage. Input divider resistors maintain the 0 to 0.5 grid voltage range for all instrument voltage ranges. The input resistance of the instrument in the VTVM position is 10 megohms.

CONVERTER.—All a.c. measurements are made by first converting the a.c. input to a d.c. voltage. The converter provides a maximum d.c. output of 5 volts for a maximum a.c. input of 5 volts rms. In the 5-volt a.c. position, range switch sections of S2A and S2B couple the 5-volt a.c. input directly to the first converter amplifier (refer to figure 6-6). In the 50-volt and 500-volt a.c. positions, input attenuators reduce the unknown a.c. to provide a maximum of 5-volts a.c. input to the first converter amplifier.

The overall frequency response of the converter is essentially flat from 30 Hz to 10kHz.

Precautions in the Use of Meters

The following are guides for the proper use of meters.

1. An ammeter is always connected in series—NEVER in parallel.
2. A voltmeter is always connected in parallel.
3. An ohmmeter is NEVER connected to a live circuit.
4. Polarity must be observed in the use of a d.c. ammeter or a d.c. voltmeter.

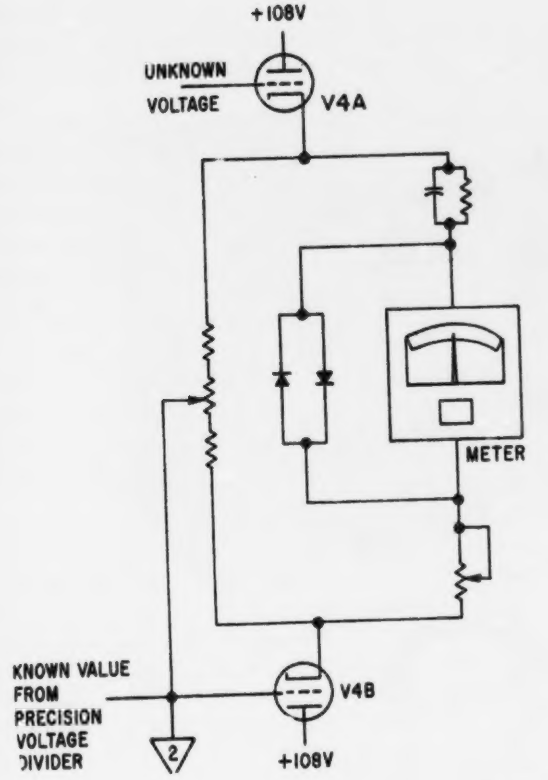


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Figure 6-8.—Differential Amplifier.

5. Meters should be viewed directly from the front. When they are viewed from an angle off to the side, an incorrect reading will result because of optical parallax.

6. Always choose an instrument suitable for the measurement desired.

7. Select the highest range first, and then switch to the proper range. The proper range is the one that allows an indication as near midscale as possible.

8. Do not mount or use instruments in the presence of a strong magnetic field.

9. Remember, a low internal resistance voltmeter (low sensitivity) will shunt a low-impedance circuit being measured and cause incorrect readings.

Bridge Circuits

An instrument employing a bridge circuit should be used in the measurement of resistance, capacitance, and inductance where a high degree of accuracy is desired. Bridge circuits are used in both a.c. and d.c. measuring instruments. Since these types of bridge circuits are discussed in detail in *Basic Electricity*, NAVPERS 10086-B, only the equipment with which we as FTBs are most commonly concerned will be covered. The bridge most likely to be encountered by us is the R-C-L bridge, AN/URM-90. One example of its use is in the verification of the MTRE Mk 7.

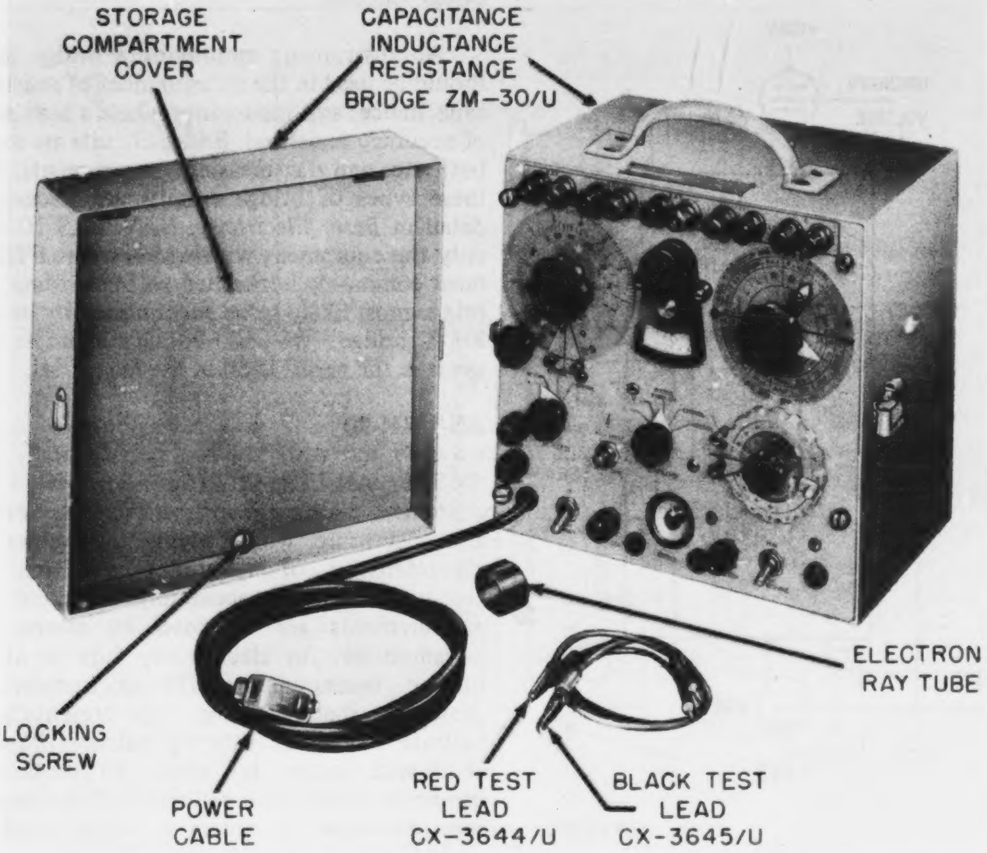
AN/URM-90

The AN/URM-90 (fig. 6-9) is a self-contained, dial-face instrument used in electrical and electronic work where the values and characteristics of resistors, capacitors, and inductors must be accurately measured. D.c. measurements are obtained by means of a galvanometer. An electron-ray tube is utilized for a.c. measurements. The electron-ray tube provides a shadowed-angle type presentation to indicate conditions of bridge balance. When the shadowed angle is wide, an unbalanced condition exists. The calibrated dials should be adjusted so as to obtain a narrow shadowed angle. This indicates a balanced bridge.

The AN/URM-90 has a 1000-Hz internal power source. If, however, measurements are desired at some other frequency, the set has an operating frequency range of 100 to 10,000 Hz when used in conjunction with an appropriate oscillator. The useable range for each function is as follows:

1. Resistance—0.1 milliohm to 11 megohms.
2. Capacitance—0.1 micromicrofarad to 1100 microfarads.
3. Inductance—0.1 microhenry to 1100 henrys.

The FTB using this model of bridge will need detailed operational instructions. These


STORAGE COMPARTMENT COVER
CAPACITANCE INDUCTANCE RESISTANCE BRIDGE ZM–30/U
ELECTRON RAY TUBE
LOCKING SCREW
POWER CABLE
RED TEST LEAD CX-3644/U
BLACK TEST LEAD CX-3645/U

20.335(167)

Figure 6-9.—R-L-C Bridge, AN/URM-90.

details are contained in the technical manual for this test equipment set, TM-2646AC1.

Oscilloscopes

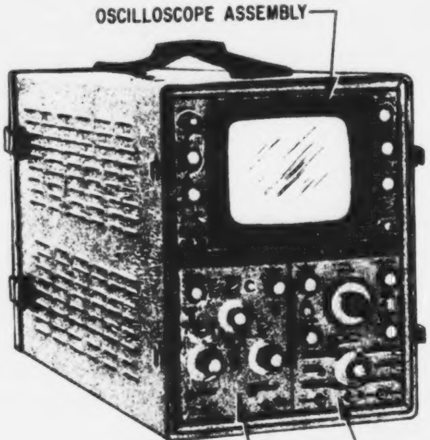
As the Fire Control Technicians concerned with the operation and maintenance of the Mk 88 POSEIDON fire control system, we will become very familiar with oscilloscopes. The usefulness of an oscilloscope lies in its ability to portray, graphically and instantaneously, fluctuating circuit conditions. This includes timing pulses, logic conditions, waveform analysis, and several other critical and useful functions.

Oscilloscope AN/USM-281

Fire Control Technicians are primarily concerned with the AN/USM-281 in the maintenance of the fire control system. It is one of the more sophisticated oscilloscopes in use today. This unit has the feature of dual-trace display. It is a direct-coupled, wideband oscilloscope that provides a visual display of simple and complex waveforms. In addition to displaying waveforms, the oscilloscope provides the user with the capability of accurately measuring the rise time of any portion of a waveform, waveform magnitude, time difference between any two points on a displayed waveform, and accurate time comparison of two separate waveforms. Figure 6-10 illustrates the AN/USM-281 and its associated equipment.

OPERATIONAL DESCRIPTION.–The OCSILLOSCOPE ASSEMBLY A1 (figure 6-11) provides the circuitry, including the low- and high-voltage power supplies, for projecting a beam onto the crt screen and the controls to adjust intensity, focus, and horizontal position of the beam on the crt. This unit also contains a horizontal amplifier to amplify the selected time-base signal and provide a linear deflection voltage to the horizontal plates of the crt. This assembly also contains the power switch, scale illumination control, and two calibrator output jacks.

The TIME BASE AND DELAY GENERATOR A3 (figure 6-11) receives operating power from the low-voltage power supply through a connector on the rear of the unit. This assembly generates the accurate time base and delay time-base voltages used for horizontal deflection during normal operation. Front panel controls provide a choice of four modes of operation: main sweep only, mixed sweep, delayed sweep, and single sweep. With the sweep mode selected, a concentric front panel control provides a choice of 23 sweep speeds for the main sweep and 18 sweep speeds for the delayed sweep. The time-base assembly also provides controls for selecting automatic or triggered time base, trigger source, polarity, level, frequency range and a calibrated, ten-turn control for precise measurement of the delay time from the trigger signal to the start of the delayed sweep.



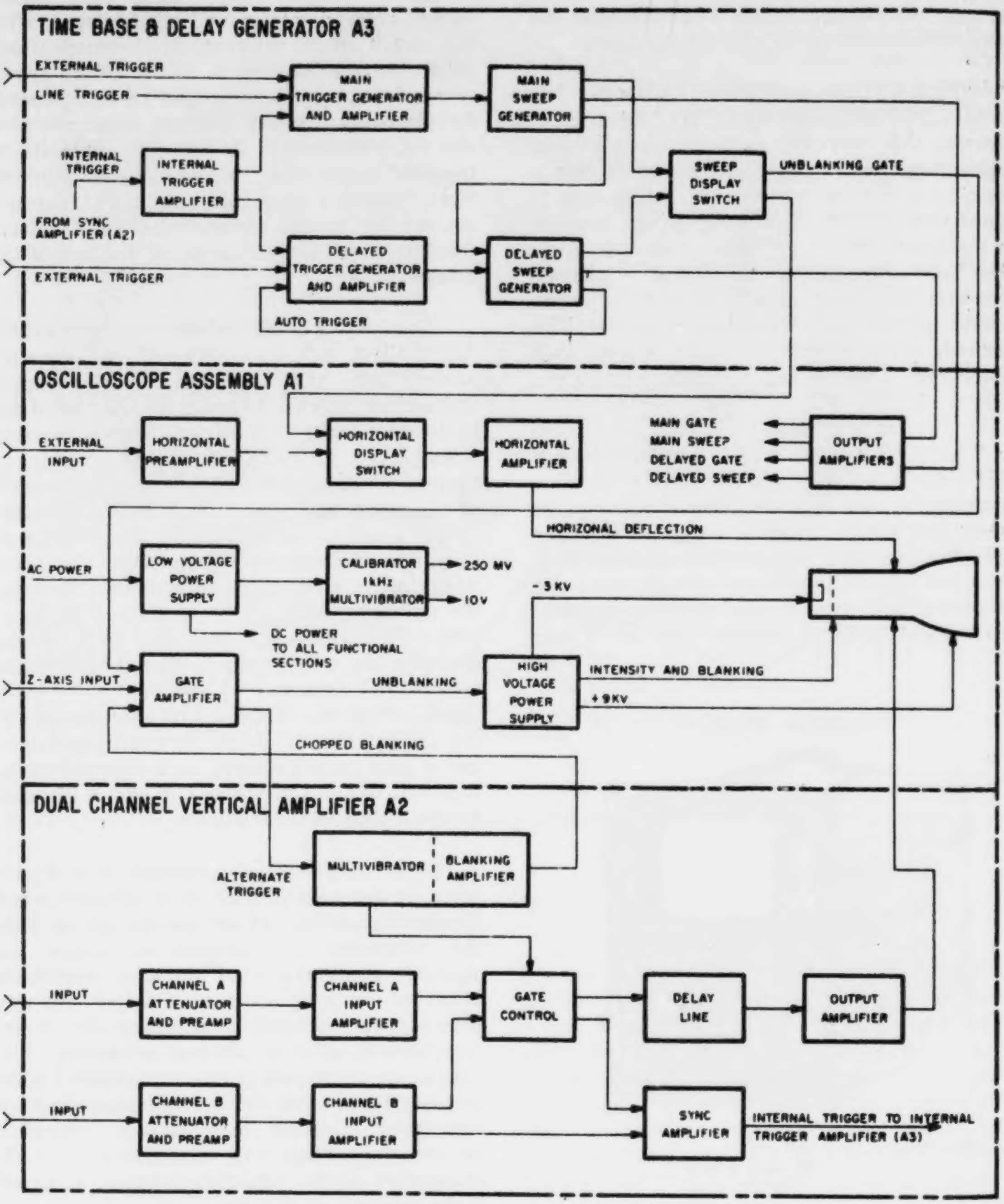
1.86.11

Figure 6-10.–Oscilloscope AN/USM-281.

The DUAL CHANNEL VERTICAL AMPLIFIER A2 (fig. 6-11) receives operating power from the low-voltage power supply through connection to the time base and delay generator unit. The dual-channel vertical amplifier contains two separate frequency-compensated d.c. amplifiers capable of displaying waveforms from d.c. to 50 MHz. Front panel controls provide three types of operation: a single trace using either channel, a single trace algebraically combining the inputs of the two separate channels, and three modes of dual-trace operation. The dual-trace modes available are: a dual trace displayed on alternate sweeps and triggered by the composite input signal, a dual trace displayed on alternate sweeps and triggered by the B channel input signal only, and a dual trace displayed on a chopped sweep that switches at a 400 kHz rate and is triggered by the B channel input signal.

Front panel polarity switches provide for inverting the waveform on either channel, when displayed separately or alternately, and to allow the technician or operator to choose the algebraic combination of the two waveforms displayed on a single trace. Controls are also provided for vertically positioning each trace, d.c. balance of each channel separately, d.c. balance of combined channels, calibrated input attenuation of each channel, X5 magnification, and input coupling selection (a.c. or d.c.). Detailed information on operation and circuit description of the AN/USM-281 may be found in the corresponding technical manual.

OSCILLOSCOPE OPERATIONAL PRECAUTIONS.–Some precautionary notes on


TIME BASE & DELAY GENERATOR A3
EXTERNAL TRIGGER
LINE TRIGGER
MAIN TRIGGER GENERATOR AND AMPLIFIER
MAIN SWEEP GENERATOR
INTERNAL TRIGGER
INTERNAL TRIGGER AMPLIFIER
FROM SYNC AMPLIFIER (A2)
SWEEP DISPLAY SWITCH
UNBLANKING GATE
DELAYED TRIGGER GENERATOR AND AMPLIFIER
DELAYED SWEEP GENERATOR
EXTERNAL TRIGGER
AUTO TRIGGER
OSCILLOSCOPE ASSEMBLY A1
EXTERNAL INPUT
HORIZONTAL PREAMPLIFIER
HORIZONTAL DISPLAY SWITCH
HORIZONTAL AMPLIFIER
MAIN GATE
MAIN SWEEP
DELAYED GATE
DELAYED SWEEP
OUTPUT AMPLIFIERS
HORIZONAL DEFLECTION
AC POWER
LOW VOLTAGE POWER SUPPLY
CALIBRATOR 1kHz MULTIVIBRATOR
250 MV
10 V
- 3 KV
DC POWER TO ALL FUNCTIONAL SECTIONS
Z-AXIS INPUT
GATE AMPLIFIER
UNBLANKING
HIGH VOLTAGE POWER SUPPLY
INTENSITY AND BLANKING
+ 9 KV
CHOPPED BLANKING
DUAL CHANNEL VERTICAL AMPLIFIER A2
ALTERNATE TRIGGER
MULTIVIBRATOR
BLANKING AMPLIFIER
INPUT
CHANNEL A ATTENUATOR AND PREAMP
CHANNEL A INPUT AMPLIFIER
GATE CONTROL
DELAY LINE
OUTPUT AMPLIFIER
INPUT
CHANNEL B ATTENUATOR AND PREAMP
CHANNEL B INPUT AMPLIFIER
SYNC AMPLIFIER
INTERNAL TRIGGER TO INTERNAL TRIGGER AMPLIFIER (A3)

1.86.11

Figure 6-11.—AN/USM-281, Functional Block Diagram.

oscilloscopes in general that should be adhered to by technicians and operators are as follows:

1. Do not apply more than the recommended voltage to either the vertical or horizontal input connector or to the test prods.
2. Prior to turning the equipment on, set the INTENSITY control fully counter-clockwise to avoid excessive intensity and possible burning of the crt screen during warmup.
3. Allow at least two inches of clearance at the rear and each side of the oscilloscope so that its forced air cooling system can operate efficiently.
4. Prevent warm air exhausted by other equipment from entering the air intake at the rear of the oscilloscope.
5. Inspect the air filter biweekly (or as directed) and clean as necessary. Clean it by dipping in warm soapy water, being sure to rinse and dry thoroughly before replacing.
6. Add one or two drops of 10-weight machine oil to the fan motor bearings every six months.

Obviously, there are various other types of test equipment required to troubleshoot, repair, and maintain the electronic and electrical circuitry that we are responsible for. These items are specified in most procedural documentation required to accomplish SMPs and PMMPs. Additional information on basic meters and test equipment is in *BASIC ELECTRICITY* and *BASIC ELECTRONICS* training manuals.

Protective Packaging

It should be obvious that in the course of maintenance and troubleshooting, we will discover modules and components that are either defective or out of tolerance and must be replaced with spares. These components must be returned to the supply system for ultimate repair/adjustment and calibration at a rework facility.

Care in handling and protection from damage are just as important for a defective module that can be repaired as for a new module. A new module receives special handling and protection against all normally encountered situations that could either damage or destroy. Modular assemblies are shipped in accordance with the applicable packaging specifications. When the issuing activity receives the assembly, the outer casing (crate or carton with the paper packing) is removed, and the assembly is stored in a watertight package until drawn by the using activity. Thus, the using activity receives with the new module the necessary packaging material to properly protect a defective module.

The correct methods and the proper material to use for protective packaging of defective modular assemblies are shown in figure 6-12. The material shown is available to all activities and should be used as prescribed for storing or transferring defective modules until they are received by a shipping facility. At that point the modules will be properly packaged for the trip to the factory or restoration facility.

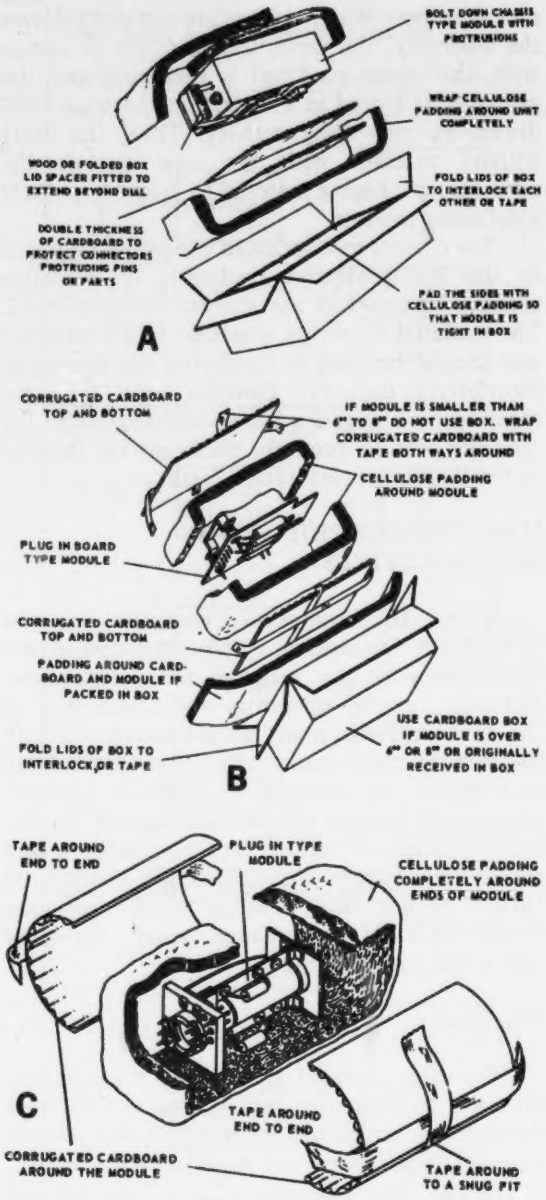
MAINTENANCE PHILOSOPHY AND OBJECTIVES

With something as complex as the POSEIDON fire control system, there must be a vast, comprehensive program for maintenance. Normally, as the operators and technicians of the fire control system, we are concerned with the level of maintenance strictly at the location to which we are assigned. However, you should realize that there is tremendous support for the entire system at various stations, military and civilian complexes, throughout the continental United States and selected host countries. Following is the maintenance "story" as related to our fire control system.

Objectives

The objectives of the overall maintenance plan are to minimize repair time, to decrease demands on maintenance personnel, and to limit onboard repair parts and support requirements.

Repair time consists of the time for the detection of a fault, the time for fault diagnosis and location, the time for replacement of the faulty part, and the time required for equipment verification after fault correction. Repair time may be minimized through the effective employment of preventive and corrective maintenance and verification procedures.


BOLT DOWN CHASSIS TYPE MODULE WITH PROTRUSIONS
WRAP CELLULOSE PADDING AROUND UNIT COMPLETELY
WOOD OR FOLDED BOX LID SPACER FITTED TO EXTEND BEYOND DIAL
FOLD LIDS OF BOX TO INTERLOCK EACH OTHER OR TAPE
DOUBLE THICKNESS OF CARDBOARD TO PROTECT CONNECTORS PROTRUDING PINS OR PARTS
PAD THE SIDES WITH CELLULOSE PADDING SO THAT MODULE IS TIGHT IN BOX
A
CORRUGATED CARDBOARD TOP AND BOTTOM
IF MODULE IS SMALLER THAN 6" TO 8" DO NOT USE BOX. WRAP CORRUGATED CARDBOARD WITH TAPE BOTH WAYS AROUND
CELLULOSE PADDING AROUND MODULE
PLUG IN BOARD TYPE MODULE
CORRUGATED CARDBOARD TOP AND BOTTOM
PADDING AROUND CARDBOARD AND MODULE IF PACKED IN BOX
USE CARDBOARD BOX IF MODULE IS OVER 6" OR 8" OR ORIGINALLY RECEIVED IN BOX
FOLD LIDS OF BOX TO INTERLOCK,OR TAPE
B
TAPE AROUND END TO END
PLUG IN TYPE MODULE
CELLULOSE PADDING COMPLETELY AROUND ENDS OF MODULE
C
TAPE AROUND END TO END
CORRUGATED CARDBOARD AROUND THE MODULE
TAPE AROUND TO A SNUG FIT

70.126

Figure 6-12.—Protective Packaging.

Maintenance demands on Fire Control Technicians are decreased through the use of fire control system automatic self-test programs. Once a failure of the fire control equipment has been made apparent by an alarm printout, alarm indication, operational failure, or failure of a readiness test, the failed type 3 module must be located and replaced as rapidly as possible to minimize the time loss of system readiness. The diagnostic goal is to isolate the failure to a group of approximately five type 3 modules. This group of type 3 modules will be replaced by onboard ready spares. This practice in most cases will restore the system to operational readiness in the shortest possible time. Further isolation to a specific type 3 module can be accomplished at a future time.

Proper preventive maintenance procedures serve as an aid in keeping equipment in service, thereby limiting onboard repair parts and support requirements.

Maintenance Levels

Four maintenance levels have been established as aids in maintaining the fire control system. Each successive maintenance level involves its own specialized requirements in personnel training, material support, test equipment, facilities, and technical documentation. The four maintenance levels are:

1. First level – Submarine
2. Second level – Tender
3. Third level – Depot (government)
4. Fourth level – Depot (commercial)

FIRST-LEVEL MAINTENANCE.–First-level maintenance consists of routine preventive maintenance, corrective maintenance, and emergency repairs performed onboard the submarine while on patrol or alongside the tender. Maintenance performed at this level is restricted to procedures that require only tools and test equipment normally provisioned for the submarine. The first-level maintenance plan provides for the submarine to be supported by the necessary onboard repair parts, tools, test equipment, and maintenance documentation.

Because first-level maintenance is the primary level with which we are usually concerned, let's examine it in a little more detail.

Preventive Maintenance.—Preventive maintenance tasks, performed as a part of first-level maintenance, include visual inspection of all components for signs of wear and deterioration, cleaning, lubrication, and adjustment procedures. Operational tests, consisting of DCC and peripheral equipment tests, fire control system tests, and missile and guidance tests are also included in the preventive maintenance plan. All preventive maintenance procedures are presented in the PMMP. These procedures are performed periodically to minimize or elminate certain types of failures.

Testing.—Automatic or manual testing of the fire control system equipment can be performed from ITOP which controls the use of built-in fire control test equipment. Testing also involves the performance of periodic (daily, weekly, and monthly) operational readiness tests to verify system operability while the submarine is on patrol.

Troubleshooting.—Troubleshooting procedures performed at the first level of maintenance are limited to isolating a malfunction to the lowest replaceable component, the type 3 module, or an equivalent nonmodular part.

Repair and Replacement.—The level at which fire control equipment components are repairable or replaceable is determined by the type and quantity of replacements provisioned for the submarine.

Maintenance of type 2 modules is restricted to emergency wire-wrap repairs only. Type 2 modules are not spared on the submarine and, therefore, not replaceable while on patrol. An emergency situation exists if type 2 module wire-wrap has been damaged in any way. Emergency wire-wrap procedures for type 2 modules are contained in OD 23446.

Routine maintenance of a type 3 module consists only of replacement of the failed module. Repair of a failed type 3 module onboard the submarine is authorized only in case of an emergency. An emergency exists only when the onboard replacement modules, which are essential to the completion of a patrol, are depleted. Emergency repair of type 3 modules aboard a tender is authorized only if the supply of spare modules is exhausted and if additional spares cannot be obtained from the supply system within the time required. Except under conditions outlined above, type 3 modules will be repaired at the Module Maintenance Facility (MMF), Charleston, S.C. Emergency repair of type 3 modules will be undertaken only if necessary spare parts are available, supporting documentation is aboard, and technicians with the necessary skill levels are present. Repair will be performed only if the repair itself does not affect the performance of other properly operating equipment.

In any case, whenever a type 2 or type 3 module has failed, and emergency repair procedures have been performed onboard the submarine, that module will be turned in to the tender for replacement at the next tender availability. The tender will inspect, repair, and return the module to the supply system. If it cannot be repaired at the tender facility, the module will be returned to the Repair and Return (R and R) facility.

Maintenance performed on cables and wiring harnesses is authorized only in an emergency. Repaired cables and harnesses will be turned over to the tender for recertification or replacement during the next tender availability.

SECOND-LEVEL MAINTENANCE.—Second-level maintenance, performed onboard a tender, consists of maintenance support in the form of repair, adjustment and calibration, and testing services. The tender serves as a supply base for the submarine and maintains an inventory of repair parts to support fire control equipment installed on the FBM submarine.

While the submarine is alongside the tender, failed material is turned into the tender for repair or replacement. The submarine also replenishes repair parts, conducts fire control equipment tests, performs equipment adjustments and calibration, and accomplishes modifications to equipment during tender availability.

THIRD-LEVEL MAINTENANCE.–Third-level maintenance is performed at the Fleet Ballistic Missile (FBM) MMF at Charleston Naval Shipyard. Maintenance performed at MMF consists of repairs on most fire control and support equipment repairable modules, including photoelectric assemblies. Third-level maintenance is also concerned with overhaul and modification of fire control system equipment.

FOURTH-LEVEL MAINTENANCE.–Fourth-level maintenance is performed at the manufacturer's facility where complete capabilities for manufacture, repair, overhaul, test, and calibration of equipment are available. The purpose of fourth-level maintenance is to provide support for the first three levels of maintenance.

Repairs at the fourth level of maintenance include type 2 and 3 modules, and other fire control equipment that is beyond repair capabilities available at the first three maintenance levels.

Tools and Test Equipment

Tools and test equipment provisioned for the submarine and tender are listed and described in OP 3141. The tender has Module Test Set (MOTS) Mk 412 and other standard test equipment and tools required to support preventive maintenance and corrective maintenance.

In general, you will have onboard the FBM submarine all the normal spares that the average system and crew will require for completion of a patrol. In the event that you are unable to obtain enough spares for a certain problem, you must perform emergency repairs.

In this chapter, we have discussed the TESS in general, safety in general, key test equipment that you are likely to encounter, and briefly, the overall scope of system maintenance. You will learn much more about maintenance and testing as you get experience and make progress in your career. Hoepfully, this chapter has given you an insight into these areas and the background you need for future progress.

In the next chapter we will discuss administration as it relates to the fire control system and to you.

CHAPTER 7

POSEIDON MISSILE AND MISSILE LAUNCHING SYSTEM

INTRODUCTION

The fleet ballistic missile (FBM) has been continually changing as a result of test flight evaluations, tests performed by submarine and support activities, and suggestions by military and civilian missile-oriented personnel. Many of these changes, plus a new design, were coordinated and developed into the POSEIDON missile system. The POSEIDON missile is larger than its predecessor, the POLARIS missile. Its electronics are more sophisticated. A major result of this is a guidance system with a greater degree of accuracy. The POSEIDON has a longer range and is capable of four separate multiple reentry body configurations, giving it a wider selection of targets than the POLARIS missile.

Before proceeding with the discussion of the POSEIDON missile, let us quickly review the operation of the overall POSEIDON FBM weapon system.

In addition to the POSEIDON missile itself, the weapon system consists of the following subsystems:

Ship

Navigation

Missile Test and Readiness Equipment (MTRE)

Fire control

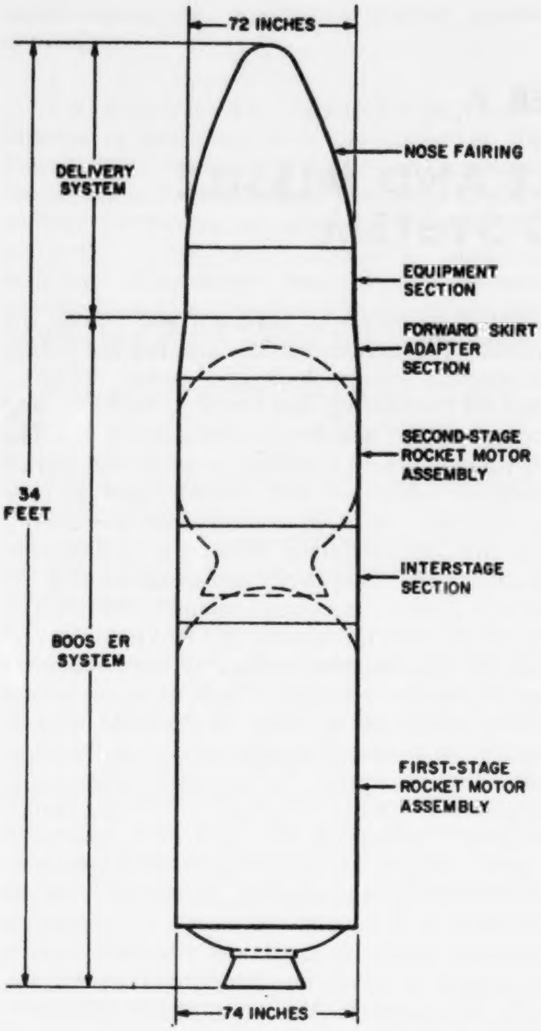
Launcher

Integrated Data Acquisition Subsystem (IDAS)

The ship system provides a mobile base for the FBM weapon system complete with all services necessary to maintain and launch the missile. The services provided are electrical power, pneumatic power, hydraulic power, environmental monitoring and control, hovering and compensation, and internal communications. The navigation system constantly monitors submarine location (longitude and latitude) and attitude (pitch, yaw, and roll) and transmits this data to the fire control system, where it is used in computing missile trajectory and programming the missile guidance electronics assembly. Missile Test and Readiness Equipment (MTRE) prepares and checks out the missiles to determine readiness conditions for a launch. The fire control system serves as the nerve center of the FBM weapon system. It monitors all other systems and accepts data that is required for successful launch and flight of a POSEIDON missile. During a launch sequence, operation of all systems is controlled by fire control. The missile launcher system provides the means of ejecting the missile from the submarine. It isolates the missile from possible damage caused by shock and vibration while it is aboard the submarine. Integrated Data Acquisition Subsystem (IDAS), a nontactical subsystem, provides the means of processing and recording FBM weapon system performance data during test programs.

PHYSICAL DESCRIPTION

THe POSEIDON missile, figure 7-1, is a solid-propellant ballistic missile weighing approximately 65,000 pounds. The POSEIDON is inertially guided and has intermediate range. POSEIDON is considered to be a two-stage missile. However, it has a third stage, the equipment section, that is capable of powered flight. The equipment section includes a gas generator and eight thruster


72 INCHES
DELIVERY SYSTEM
NOSE FAIRING
EQUIPMENT SECTION
FORWARD SKIRT ADAPTER SECTION
SECOND-STAGE ROCKET MOTOR ASSEMBLY
34 FEET
INTERSTAGE SECTION
BOOSTER SYSTEM
FIRST-STAGE ROCKET MOTOR ASSEMBLY
74 INCHES

173.299

Figure 7-1.—The POSEIDON missile.

valves that provide an omnidirectional translational maneuverability. The maneuverable equipment section allows POSEIDON to deliver its multiple reentry bodies to a signal target or to multiple targets. In addition to orienting the equipment section, the gas generator can be used for adding downrange distance to the total flight of the POSEIDON missile. Some of the missile operating parameters are listed in table 7-1.

Table 7-1.—POSEIDON Missile Operating Parameters

Capability	Description
Launch conditions	Surface or submerged launch from SSBN
Range (launch point to target)	Between 500 and 3,500 nautical miles
Payload	Multiple reentry bodies
Lofting	Capable of variable loft angles
Maneuverable equipment section	Permits deployment of multiple reentry bodies to multiple targets or to a single target

The missile sections, figure 7-1, are commonly grouped to form two systems, the booster system and the delivery system. The booster system consists of the first-stage rocket motor assembly, interstage section, second-stage rocket motor assembly, and forward skirt adapter section. The delivery system consists of the equipment section and nose fairing.

The booster system provides controlled thrust that places the missile in the proper trajectory during the boost phase of flight. Boost phase of flight consists of first- and second-stage powered flight. The delivery system provides the control forces for obtaining the precise attitude and velocity for multiple reentry body release during the deployment phase of flight. The deployment phase of flight consists of equipment section flight and reentry body release.

POSEIDON MISSILE SUBSYSTEMS

Functionally, each missile comprises the following subsystems:

Electrical

Guidance

Flight control

Ordnance

Propulsion

Ballistic shell

Reentry

Figure 7-2 illustrates the missile's primary in-flight functions required to place the reentry body (RB) in a ballistic trajectory.

The electrical subsystem generates and distributes internal power during checkout and flight, initiates ignition and separation events, distributes external power during checkout, and transfers reentry-body-fuzing and arming signals to the reentry subsystem. The major components of the electrical subsystem are illustrated in figure 7-3.

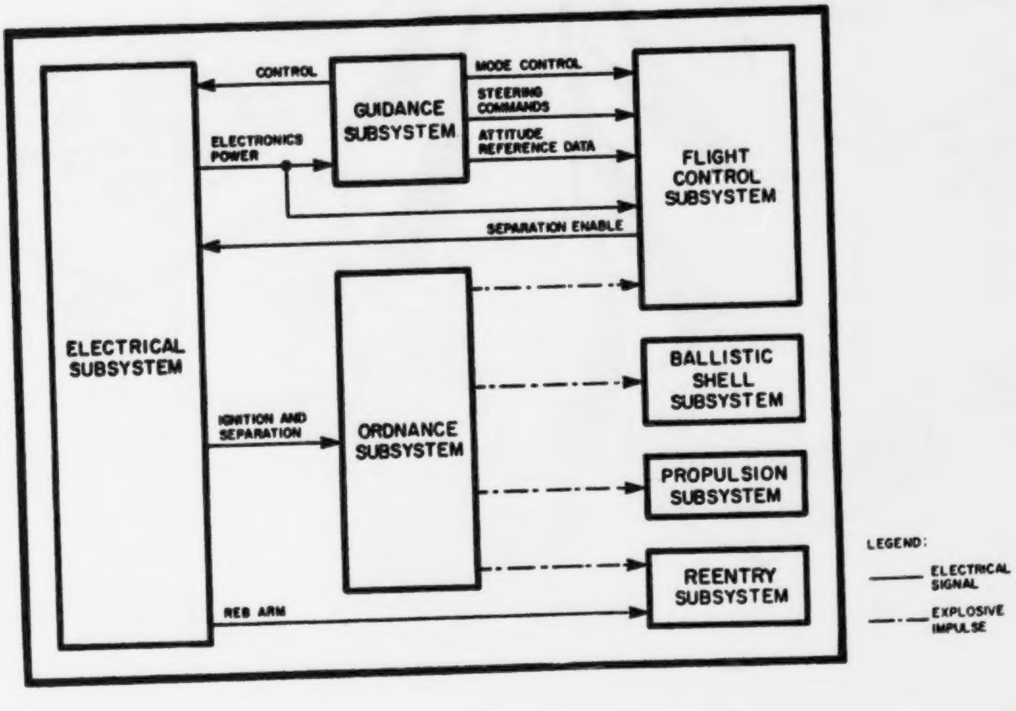
Reentry System Fuzing

The missile electrical subsystem, in conjunction with the Mk 88 fire control system, fuzes each reentry body in the reentry subsystem prior to launch. The command sequencer package (refer to figure 7-3) provides an electrical interface between the fire control system and the missile reentry subsystem.

During the prelaunch countdown, the fire control system transmits the fuze-set data to the reentry subsystem; and, just prior to launch, the information is sent back to fire control to verify that the reentry subsystem received the information correctly. This action is illustrated in the block diagram of the electrical subsystem in figure 7-4.

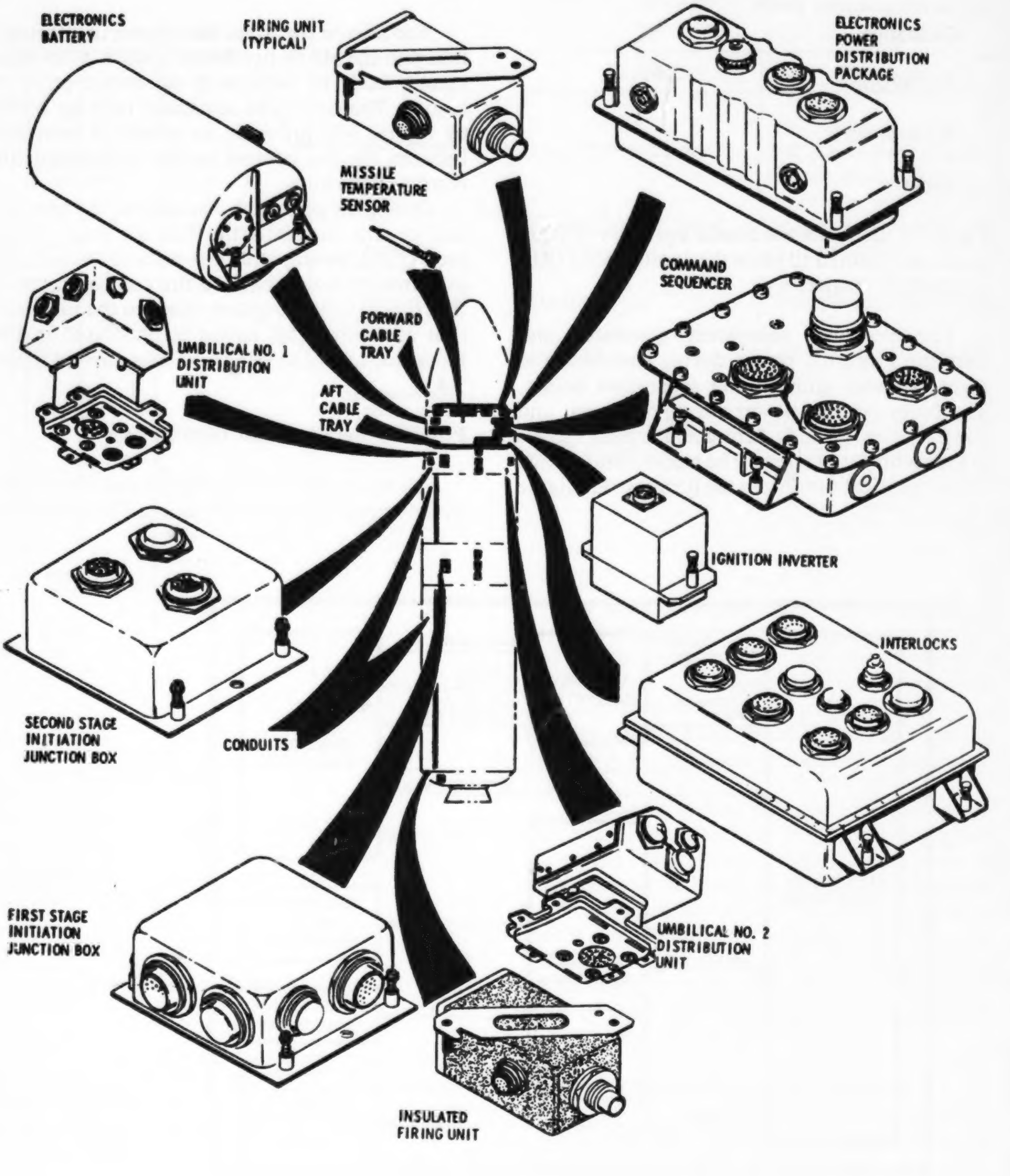
Power Generation and Distribution

All missile power is generated and distributed by the missile electrical subsystem. The electronics


CONTROL
GUIDANCE SUBSYSTEM
MODE CONTROL
STEERING COMMANDS
ATTITUDE REFERENCE DATA
ELECTRONICS POWER
FLIGHT CONTROL SUBSYSTEM
SEPARATION ENABLE
ELECTRICAL SUBSYSTEM
IGNITION AND SEPARATION
ORDNANCE SUBSYSTEM
BALLISTIC SHELL SUBSYSTEM
PROPULSION SUBSYSTEM
REENTRY SUBSYSTEM
REB ARM
LEGEND:
ELECTRICAL SIGNAL
EXPLOSIVE IMPULSE

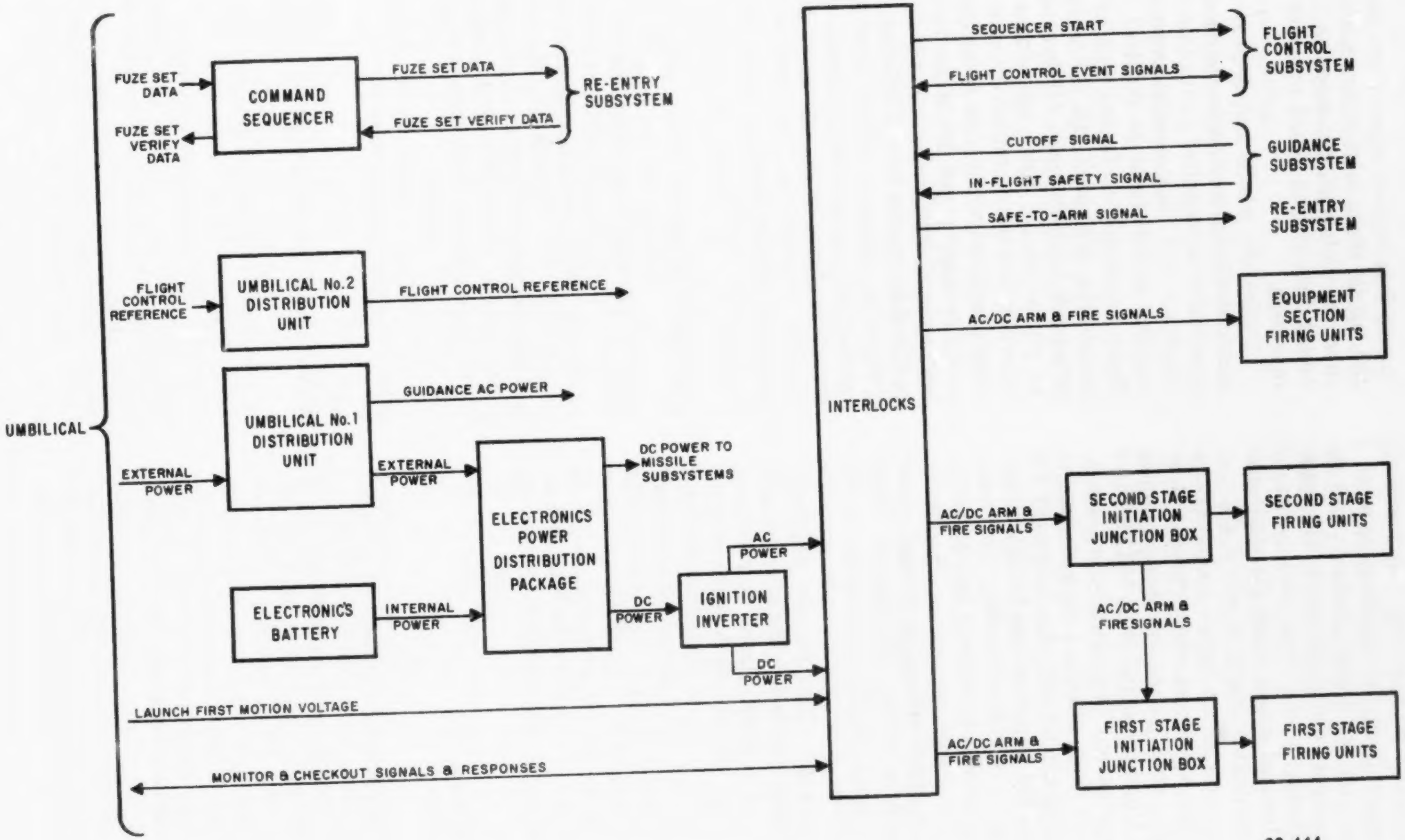
173.284

Figure 7-2.—The POSEIDON missile subsystems.


ELECTRONICS BATTERY
FIRING UNIT (TYPICAL)
ELECTRONICS POWER DISTRIBUTION PACKAGE
MISSILE TEMPERATURE SENSOR
COMMAND SEQUENCER
FORWARD CABLE TRAY
UMBILICAL NO. 1 DISTRIBUTION UNIT
AFT CABLE TRAY
IGNITION INVERTER
INTERLOCKS
SECOND STAGE INITIATION JUNCTION BOX
CONDUITS
FIRST STAGE INITIATION JUNCTION BOX
UMBILICAL NO. 2 DISTRIBUTION UNIT
INSULATED FIRING UNIT

33.400

Figure 7-3.—Electrical subsystem component location.


UMBILICAL
FUZE SET DATA
FUZE SET VERIFY DATA
COMMAND SEQUENCER
FUZE SET DATA
FUZE SET VERIFY DATA
RE-ENTRY SUBSYSTEM
FLIGHT CONTROL REFERENCE
UMBILICAL No.2 DISTRIBUTION UNIT
FLIGHT CONTROL REFERENCE
UMBILICAL No.1 DISTRIBUTION UNIT
GUIDANCE AC POWER
EXTERNAL POWER
EXTERNAL POWER
ELECTRONICS POWER DISTRIBUTION PACKAGE
DC POWER TO MISSILE SUBSYSTEMS
ELECTRONICS BATTERY
INTERNAL POWER
DC POWER
IGNITION INVERTER
AC POWER
DC POWER
LAUNCH FIRST MOTION VOLTAGE
MONITOR & CHECKOUT SIGNALS & RESPONSES
INTERLOCKS
SEQUENCER START
FLIGHT CONTROL EVENT SIGNALS
FLIGHT CONTROL SUBSYSTEM
CUTOFF SIGNAL
IN-FLIGHT SAFETY SIGNAL
GUIDANCE SUBSYSTEM
SAFE-TO-ARM SIGNAL
RE-ENTRY SUBSYSTEM
AC/DC ARM & FIRE SIGNALS
EQUIPMENT SECTION FIRING UNITS
AC/DC ARM & FIRE SIGNALS
SECOND STAGE INITIATION JUNCTION BOX
SECOND STAGE FIRING UNITS
AC/DC ARM & FIRE SIGNALS
AC/DC ARM & FIRE SIGNALS
FIRST STAGE INITIATION JUNCTION BOX
FIRST STAGE FIRING UNITS

33.444

Figure 7-4.—Electrical subsystem simplified block diagram.

power distribution package (fig. 7-4) distributes external power from the umbilical number 1 distribution unit (45-degree position) and the umbilical number 2 distribution unit (310-degree position) during missile tests and prelaunch checkout. Internal power from the electronics battery is distributed during missile flight.

The equipment section electronics battery consists of two battery sections of dry-charged silver-zinc cells, with an adjoining chamber containing electrolyte. Upon command from MTRE Mk 6 Mod 3, approximately 45 seconds before launch, the initiator is fired, causing a gas generator to force electrolyte into the cells. Approximately 200 milliseconds after activation, the battery attains full charge and is capable of standing 3 to 6 hours under no-load condition. A power transfer switch located in the electronics power distribution package selects either external or internal power on command from MTRE Mk 6 Mod 3. From the electronics power distribution package, 30-volt dc guidance power is distributed to the guidance electronics package. The 30-volt dc flight-control/ignition power is distributed to the ignition inverter and to flight control as electronics and valve power. The 30-volt dc valve power is supplied to the flight-control electronics packages. Any dc voltage other than 30 volts is developed by power supplies and ac/dc converters in the packages that require it. The ignition inverter receives 30-volt dc power and converts it to 115-volt 2-kHz ac arm power. Both ac and dc power are sent by the ignition inverter to interlocks.

Initiation of Ignition and Separation Events

The electrical subsystem initiates all ignition and separation events throughout missile flight. The times of ignition and separation events through first separation are determined by the electrical subsystem. All subsequent events are initiated by the electrical subsystem on command from the guidance or flight-control subsystems.

Interlocks is an electronic programmer that controls all ignition and separation events. Upon command from the flight-control subsystem, interlocks also generates and routes RB arming signals to the reentry subsystem. Until after missile launch, all interlocks circuits are inhibited by the launch-first-motion signal from interlocks. As the missile starts motion through the launcher tube, the umbilicals disconnect and remove the launch-first-motion signal to enable interlocks operation.

During the missile launch phase, interlocks measures missile acceleration and distance. Missile acceleration is measured during first-stage flight. Guidance and flight-control event signals are supplied to interlocks as required throughout flight. Based on these factors, interlocks supplies an ac arm, a dc arm, and a fire signal to the firing unit for each event. All three signals must be present at the firing unit for a minimum allowable time to accomplish the event. When all three signals are present, the firing unit provides a high-voltage signal to ignite an exploding bridgewire (EBW) detonator, which initiates a confined detonating fuze (CDF) that leads to the ignition or separation device. Nose fairing and reentry body signals are supplied directly to the associated firing units; all other signals are supplied through the first- and second-stage initiation junction boxes.

Guidance Subsystem

The guidance subsystem acts as a stable member for flight reference; accepts and stores prelaunch data; continuously processes data during flight; provides attitude reference signals, and issues steering and velocity commands to the flight-control subsystem; and computes the velocity-to-be-gained formulas necessary for cutoff and RB releases.

The function of the guidance subsystem was described earlier in this manual.

Flight-Control Subsystem

The flight-control subsystem steers the missile along the programmed trajectory in response to commands from the guidance subsystem. During first- and second-stage flight, steering is accomplished by directing the single movable nozzles attached to the first- and second-stage motors. During equipment section flight, steering is controlled by eight equipment section thruster valves.

The flight-control subsystem is functionally subdivided into three sections:

Electronics section

Thrust-vector control section

Reaction control section

A block diagram of the flight-control subsystem is shown in figure 7-5. The components of the flight-control subsystem and their location are illustrated in figure 7-6.

The electronics section of the flight-control subsystem converts pointing (P) and force (F) vectors from the missile guidance subsystem into steering commands for the thrust-vector control section and the reaction-control section. The electronics section also provides timing and sequencing for missile discrete events.

The flight-control electronics section consists of the following components (refer to figure 7-6):

1. Equipment section flight-control electronics package (ES FCEP)
2. Equipment section flight-control electronics package (flexiplug)
3. Second-stage flight-control electronics package (SS FCEP)
4. First-stage flight-control electronics package (FS FCEP)
5. Flight-control gyro package

The thrust-vector control section of the flight-control subsystem effects missile steering during first and second stages of missile flight. The thrust-vector control section receives electronic steering commands from the electronics section and converts these electrical signals to hydraulic control signals, which are used in controlling the movement of the first- and second-stage nozzles. Movement of the nozzles effects thrust-vector control and, therefore, accomplishes missile steering during the first and second stages of missile flight.

Thrust-vector control (TVC) components for either first or second stage are as follows:

1. Gas generator
2. Gas manifold
3. Gas manifold relief orifice
4. Hydraulic power unit (HPU)
5. Integrated hydraulic actuators assembly

The reaction-control section of the flight-control subsystem provides equipment section steering and propulsion during the deployment phase of flight (equipment section flight). In addition, the reaction-control section provides the capability of directing the equipment section in the null-range direction and stabilizing the equipment section during reentry body deployment events. Steering, thrust, and stabilization of the equipment section are accomplished by a gas generator and eight two-way thruster valves. Four of the thruster valves (type A valves) provide pitch, yaw, and thrust control along the missile

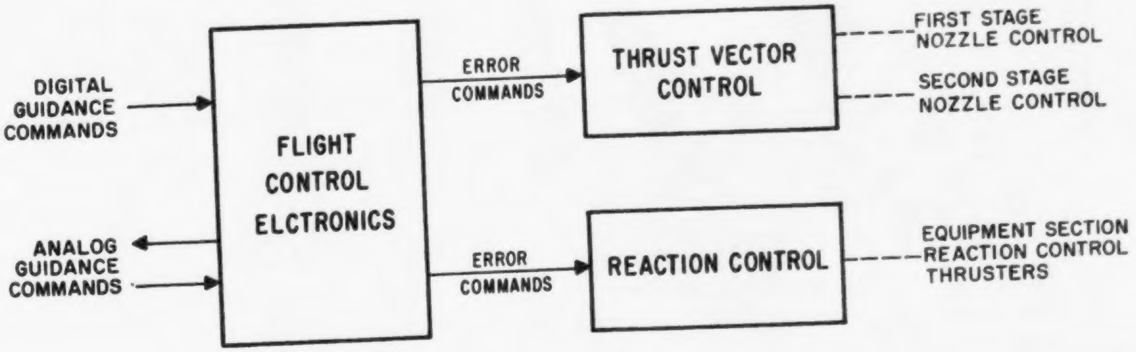
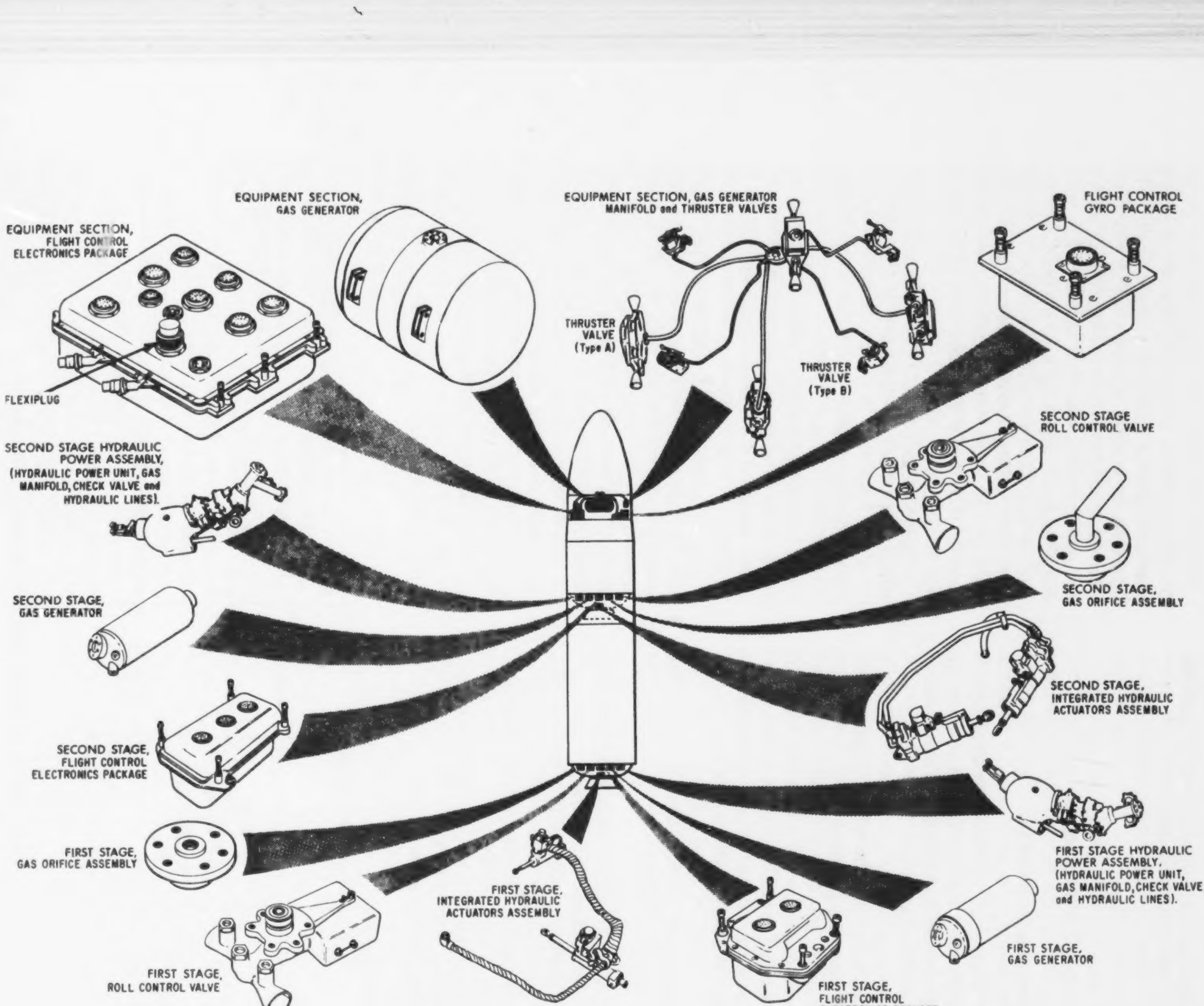

DIGITAL GUIDANCE COMMANDS
ANALOG GUIDANCE COMMANDS
FLIGHT CONTROL ELCTRONICS
ERROR COMMANDS
THRUST VECTOR CONTROL
ERROR COMMANDS
REACTION CONTROL
FIRST STAGE NOZZLE CONTROL
SECOND STAGE NOZZLE CONTROL
EQUIPMENT SECTION REACTION CONTROL THRUSTERS
33.446

Figure 7-5.—Flight-control subsystem simplified block diagram.


EQUIPMENT SECTION, FLIGHT CONTROL ELECTRONICS PACKAGE
FLEXIPLUG
EQUIPMENT SECTION, GAS GENERATOR
EQUIPMENT SECTION, GAS GENERATOR MANIFOLD and THRUSTER VALVES
THRUSTER VALVE (Type A)
THRUSTER VALVE (Type B)
FLIGHT CONTROL GYRO PACKAGE
SECOND STAGE HYDRAULIC POWER ASSEMBLY, (HYDRAULIC POWER UNIT, GAS MANIFOLD, CHECK VALVE and HYDRAULIC LINES).
SECOND STAGE ROLL CONTROL VALVE
SECOND STAGE, GAS GENERATOR
SECOND STAGE, GAS ORIFICE ASSEMBLY
SECOND STAGE, INTEGRATED HYDRAULIC ACTUATORS ASSEMBLY
SECOND STAGE, FLIGHT CONTROL ELECTRONICS PACKAGE
FIRST STAGE, GAS ORIFICE ASSEMBLY
FIRST STAGE HYDRAULIC POWER ASSEMBLY, (HYDRAULIC POWER UNIT, GAS MANIFOLD, CHECK VALVE, and HYDRAULIC LINES).
FIRST STAGE, INTEGRATED HYDRAULIC ACTUATORS ASSEMBLY
FIRST STAGE, ROLL CONTROL VALVE
FIRST STAGE, FLIGHT CONTROL ELECTRONICS PACKAGE
FIRST STAGE, GAS GENERATOR

33.447

Figure 7-6.—Flight-control subsystem component location.

longitudinal axis (X_m). The other four thruster valves (type B valves) provide roll control and propulsion along the missile lateral axes (Y_m and Z_m).

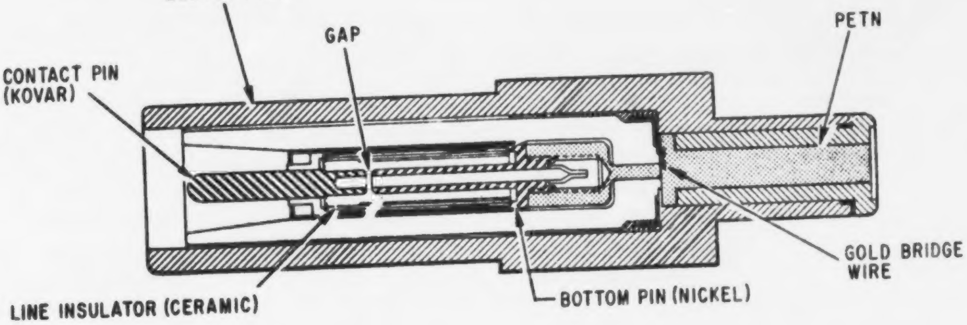
Equipment section reaction-control system (ERCS) components are as follows:

1. Gas generator
2. Gas generator manifold
3. Type A thruster valve (4)
4. Type B thruster valve (4)

The ordnance subsystem provides the means for execution of the ignition and separation events initiated by the electrical subsystem. An event is initiated by a high-voltage, high-current pulse from a firing unit in the electrical subsystem. The pulse is applied to an exploding bridgewire (EBW) detonator in the ordnance subsystem, which is a sparking source for various pyrotechnic devices. The ignition events executed by the ordnance subsystem include first-stage and second-stage rocket motor ignition; and first-stage, second-stage, and equipment section gas generator ignition. The separation events include first, second, nose fairing, and reentry body separations. Thrust termination and nose fairing jettison events are also executed by the ordnance subsystem.

When the pulse from the firing unit enters the EBW detonator, it routes an explosive impulse to a confined detonating fuze (CDF) transfer line. The CDF transfer lines transmit the explosive impulse to components of the ordnance subsystem, which are located throughout the missile. The explosive pulses are transferred from one section of the missile to another by initiation fittings, manifolds, through bulkhead initiators (TBI), tee fittings, and explosive disconnect fittings. These devices transfer an explosive impulse to ignite detonating cords, flexible linear-shaped charges (FLSC), and zipcords.

EBW DETONATOR.—The EBW detonator (fig. 7-7) contains a coaxial pin with an air gap designed to present an open circuit to a dc voltage up to 500 volts. The coaxial pin, formed by the contact pin and bottom pin, is mounted in a high-density insulator. The coaxial pin is inserted into the pin tip. A bridgewire is connected between the pin tip and a metal cup that is grounded to the metal case. The main sleeve contains a pentaerthrite tetranitrate (PETN) charge, which is installed near the bridgewire. When a firing unit applies a high-voltage, high-current surge of approximately 2400-volts dc to the contact pin, the voltage jumps the air gap and vaporizes the bridgewire, which ignites the PETN charge. The explosive impulse produced by the exploding charge detonates the pyrotechnic device connected to the EBW detonator.



161.252.1

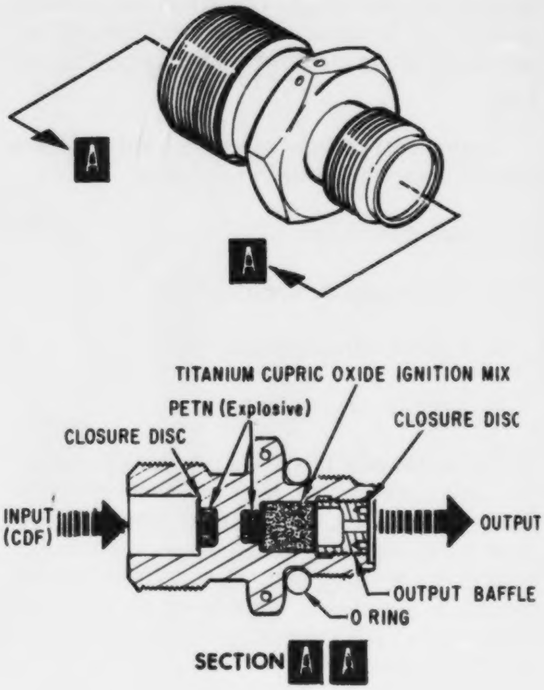
Figure 7-7.—Exploding bridgewire detonator.

CDF LINE.—The CDF line (fig. 7-8) consists of a length of CDF whose center core is an explosive charge (RDX), encased in an aluminum sheath with fittings on each end. The aluminum sheath is encased in a polyethlene sleeving, surrounded with fiber glass braid. The end fittings (of either steel or aluminum) contain booster charges, attach to the various pyrotechnic devices, and are either threaded or are equipped with quick-disconnects.

A shock wave initiated by an EBW detonator is transmitted by the cyclotrimethylene trimitramine (RDX) in the CDF as an explosive impulse traveling at approximately 20,000 feet per second. The CDF end fittings transfer the explosive impulse to other pyrotechnic devices.

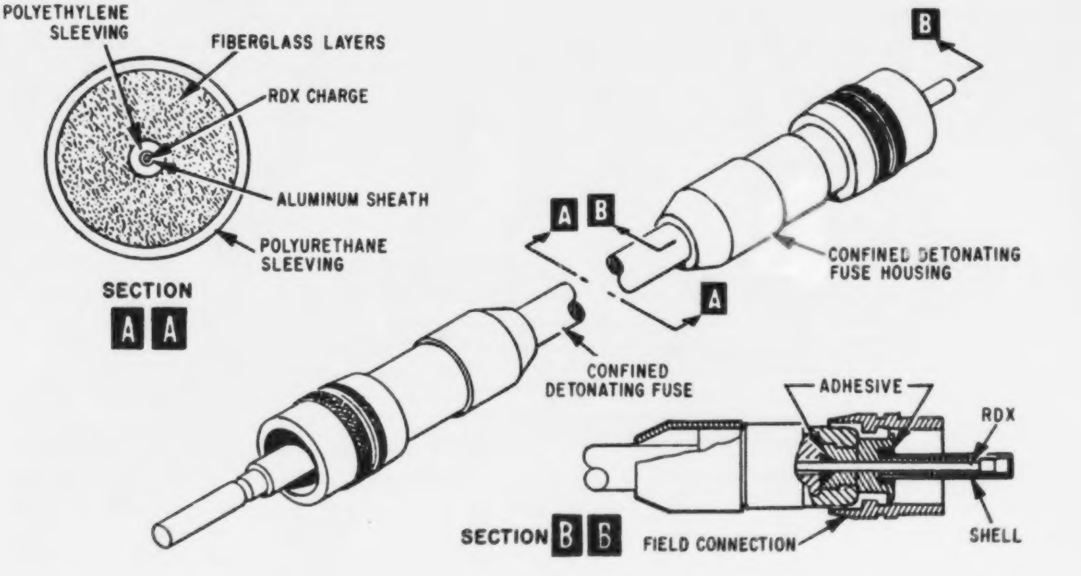
IGNITION TBI.—The ignition through bulkhead initiator (TBI) (fig. 7-9) consists of a two-cavity housing. An input cavity houses a PETN charge held in place by a closure disc; an output cavity houses an explosive mixture of titanium cupric oxide and a PETN charge.

The explosive impulse from a TBI tee fitting enters the input cavity of the TBI, causing the PETN to explode. The resulting shock wave is transmitted through the bulkhead to the PETN


A
A
TITANIUM CUPRIC OXIDE IGNITION MIX
PETN (Explosive)
CLOSURE DISC
CLOSURE DISC
INPUT (CDF)
OUTPUT
OUTPUT BAFFLE
O RING
SECTION A A

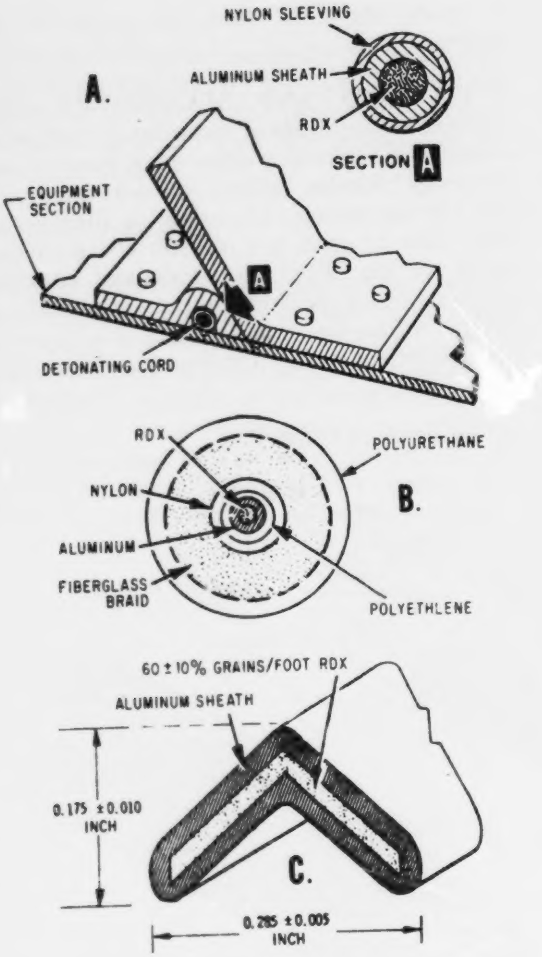
33.448

Figure 7-9.—Through bulkhead initiator.


B
POLYETHYLENE SLEEVING
FIBERGLASS LAYERS
RDX CHARGE
ALUMINUM SHEATH
POLYURETHANE SLEEVING
SECTION A A
A B
CONFINED DETONATING FUSE HOUSING
A
CONFINED DETONATING FUSE
ADHESIVE
RDX
SHELL
SECTION B B
FIELD CONNECTION

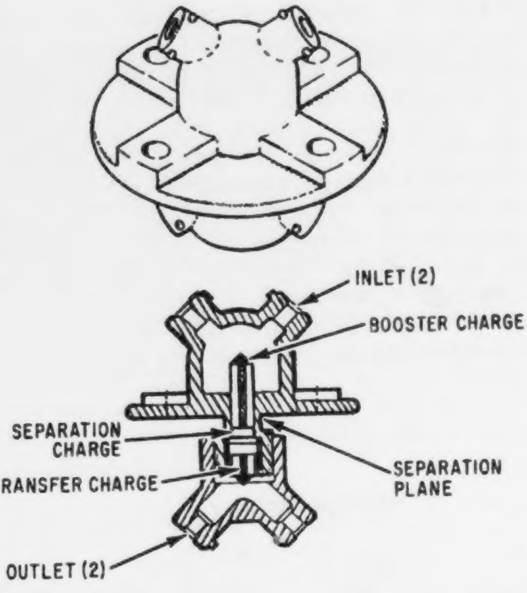
161.253

Figure 7-8.—Confined detonating fuze line.


A.
NYLON SLEEVING
ALUMINUM SHEATH
RDX
SECTION A
EQUIPMENT SECTION
A
DETONATING CORD
RDX
POLYURETHANE
NYLON
B.
ALUMINUM
FIBERGLASS BRAID
POLYETHLENE
60 ± 10% GRAINS/FOOT RDX
ALUMINUM SHEATH
0.175 ±0.010 INCH
C.
0.285 ±0.005 INCH

161.254

Figure 7-10.—A. Detonating cord and typical separation plane; B. Zipcord; C. Flexible linear-shaped charge.


INLET (2)
BOOSTER CHARGE
SEPARATION CHARGE
TRANSFER CHARGE
SEPARATION PLANE
OUTLET (2)

161.255

Figure 7-11.—Interstage section explosive disconnect.

charge on the output side of the TBI. The PETN charge explodes, igniting the pyrotechnic mixture of titanium cupric oxide, which is specifically mixed for high-caloric output. Hot gases and flame exit through an output baffle and ignite the pyrotechnic device to which the TBI is connected.

DETONATING CORD.—A detonating cord (fig. 7-10) is composed of RDX encased in an aluminum sheath with an outer nylon plastic jacket. An explosive impulse from a CDF line causes the RDX in the detonating cord to explode and cut through the desired surface of the missile. Detonating cord is placed in the three separation rings of the missile and at the thrust termination doors in the forward skirt adapter of the missile.

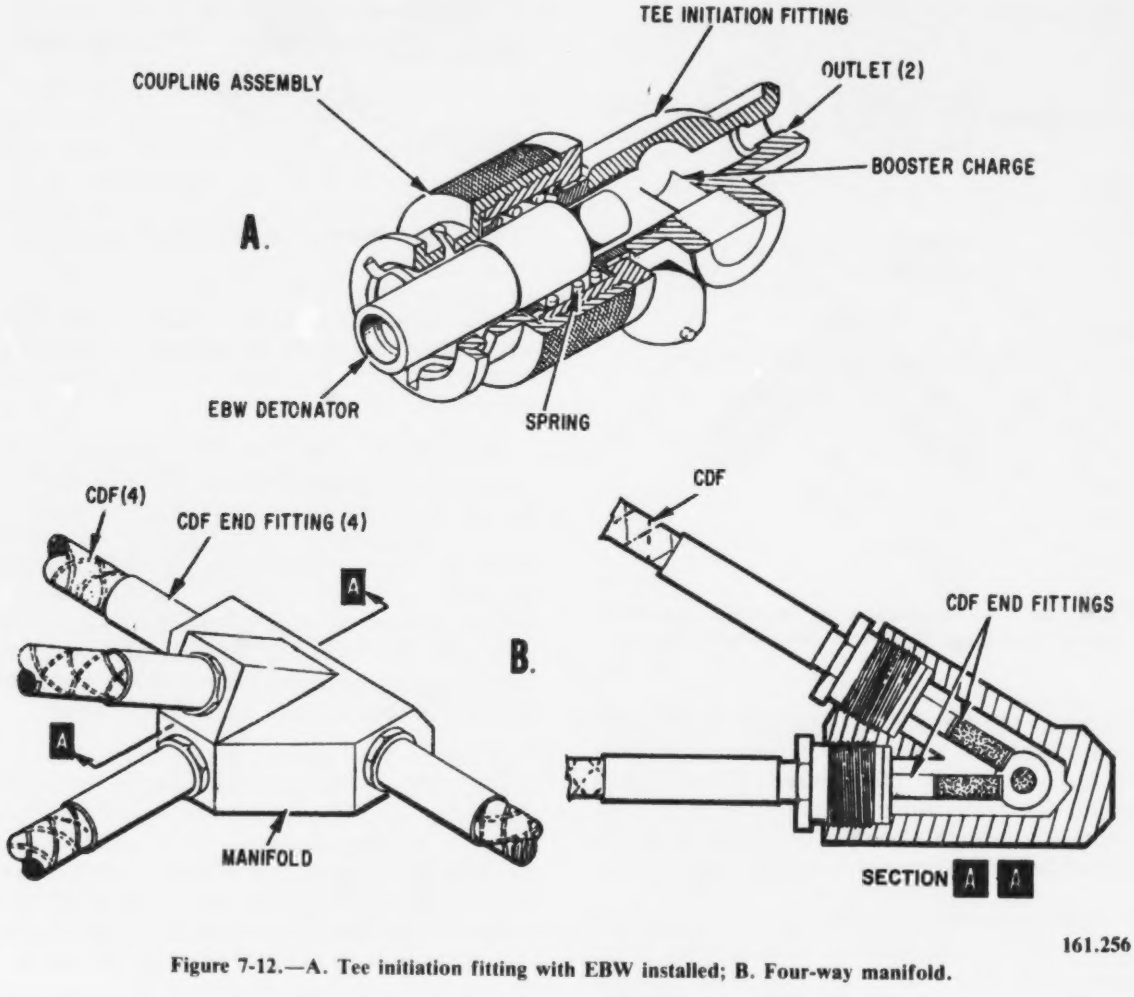
ZIPCORD.—Zipcord consists of an RDX charge (fig. 7-10, view B) encased in an aluminum and polyurethane jacket, with segments encased in an outer covering of fiber glass braid. Upon detonation by a CDF line, the zipcord transmits an explosive impulse through itself. When the impulse passes through a segment without the fiber glass braid cover, the internal pressure causes the zipcord to expand. This expansion is used to release the reentry body hold down latches.

FLSC.—The flexible linear-shaped charge (FLSC) (fig. 7-10, view C) consists of RDX encased in an aluminum sheath that has a shallow V shape. An explosive impulse from a CDF causes the FLSC to detonate. The exploding RDX causes the metal in the interior of the V-shaped charge to form a slug that cuts through the thrust termination ports in the second-stage rocket motor.

EXPLOSIVE DISCONNECT.—An explosive disconnect provides a path between its inlets and outlets for an explosive impulse (fig. 7-11).

When an impulse is applied, the body of the explosive disconnect is severed into separate parts. This type of pyrotechnic device is convenient to use for events in which the firing unit remains with the discarded (depleted) portion of the missile. For example, the second-stage gas generator is activated from an interstage section firing unit. The firing unit, having completed its task, is separated at the explosive disconnect along with the first-stage rocket motor and interstage section at the time of second-stage ignition. The explosive impulse continues through the unit to ignite the CDF lines connected to the outlets.

FITTINGS AND MANIFOLDS.—The fittings and manifolds of the ordnance subsystem consist of the following items: angle, straight, and three-way initiation fittings; four-way manifolds; and TBI tee fittings. The initiation fittings (fig. 7-12, view A) contain a transfer charge, receptacles for the EBW detonators, and attaching mechanisms for the firing units and the CDF end fitting. A four-way manifold (fig. 7-12, view B) has connection points for four CDF lines. The


TEE INITIATION FITTING
COUPLING ASSEMBLY
OUTLET (2)
BOOSTER CHARGE
A.
EBW DETONATOR
SPRING
CDF(4)
CDF END FITTING (4)
A
B.
A
MANIFOLD
CDF
CDF END FITTINGS
SECTION A A

161.256

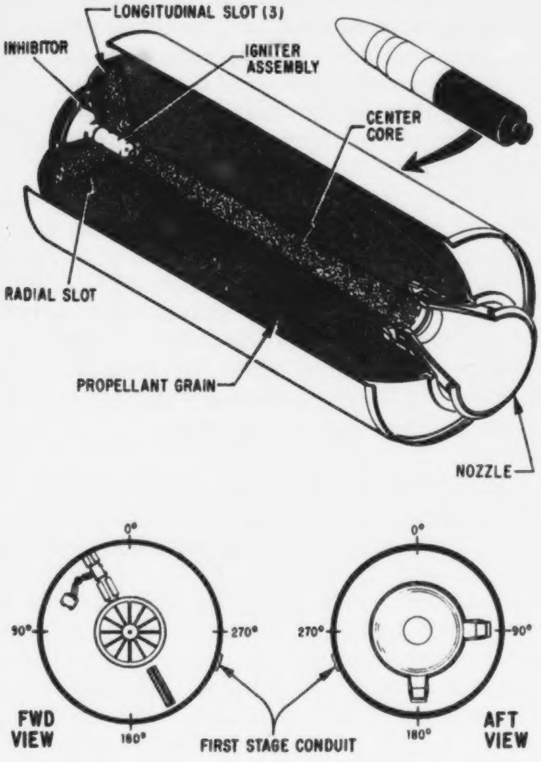
Figure 7-12.—A. Tee initiation fitting with EBW installed; B. Four-way manifold.

TBI tee fitting contains a transfer charge and has attaching mechanisms for the CDF lines and the TBI fitting. The function of these components is to provide a closed path for transferring an explosive impulse.

Propulsion Subsystem

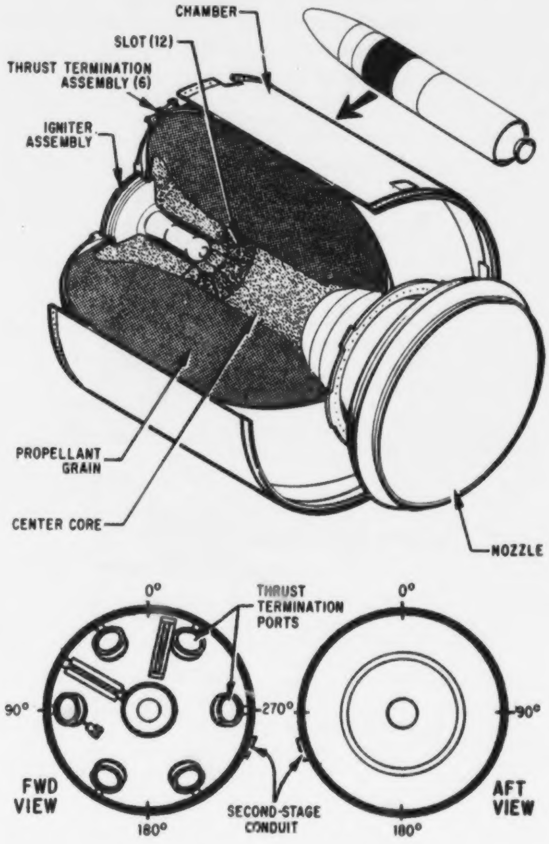
The propulsion subsystem provides thrust to accelerate the missile along a programmed flight path during the boost phase of flight. It also provides a means for thrust termination necessary for trajectory control at second-stage separation. The propulsion subsystem consists of the first- and second-stage rocket motor assemblies, as illustrated in figures 7-13 and 7-14. Both rocket motors are ignited by the ordnance subsystem when the missile has reached predetermined limits determined by guidance, flight control, and interlocks.

Separation of the first-stage rocket motor and ignition of the second-stage rocket motor occur simultaneously when missile acceleration decreases to a predetermined value. Termination of second-stage powered flight is determined by the guidance system. Second-stage powered flight is terminated by blowing six thrust termination ports in the forward end of the second-stage rocket motor. (Refer to fig. 7-14.) The rocket motor exhaust gases then escape in a forward direction, creating a reverse thrust that offsets second-stage acceleration.


LONGITUDINAL SLOT (3)
INHIBITOR
IGNITER ASSEMBLY
CENTER CORE
RADIAL SLOT
PROPELLANT GRAIN
NOZZLE
0°
90°
270°
FWD VIEW
180°
FIRST STAGE CONDUIT
0°
270°
90°
180°
AFT VIEW

33.449

Figure 7-13.—First-stage motor.


CHAMBER
SLOT (12)
THRUST TERMINATION ASSEMBLY (6)
IGNITER ASSEMBLY
PROPELLANT GRAIN
CENTER CORE
NOZZLE
0°
THRUST TERMINATION PORTS
0°
90°
270°
90°
FWD VIEW
180°
SECOND-STAGE CONDUIT
180°
AFT VIEW

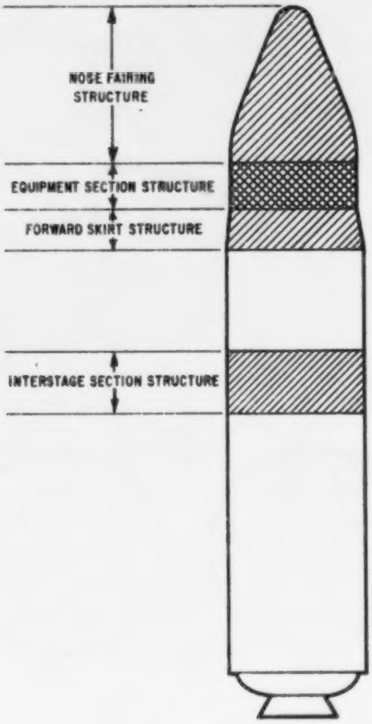
33.450

Figure 7-14.—Second-stage motor.

Ballistic Shell Subsystem

The ballistic shell subsystem (fig. 7-15) comprises the interstage section, forward skirt structure, equipment section, and nose fairing. The ballistic shell subsystem provides a protective envelope for missile components and structural interconnection between missile sections. Further, the ballistic shell subsystem provides the missile with hydrodynamic and aerodynamic stability during launch and powered flight.

INTERSTAGE SECTION STRUCTURE.—The interstage section structurally joins the first-stage motor and the second-stage motor. It provides support and protection for the various missile components housed within it. The interstage section is made of hardened aluminum alloy, weighs approximately 195 pounds, and it is 34 inches long and 74 inches in diameter. Two access doors, at the 45- and 225-degree positions, provide access to components mounted in the interstage section when the missile is assembled. Air bleed holes permit pressure equalization. In addition, with the interstage section mated to the first- and second-stage motors, the interstage section access doors provide physical access to components mounted on the forward end of the first-stage motor and to components mounted on the aft end of the second-stage motor.



33.451

Figure 7-15.—Ballistic shell subsystem.

FORWARD SKIRT STRUCTURE.—The forward skirt structure joins the second-stage motor to the equipment section and provides support and protection for the missile components housed within it. The forward skirt structure is made of hardened aluminum alloy, weighs approximately 217 pounds, and it is 24 inches long and 74 inches in diameter at the aft end, tapering to 72 inches in diameter at the forward end. Six thrust termination stacks and six thrust termination doors are equidistantly spaced around the circumference of the forward skirt structure. An access door at the 180-degree position provides access to components mounted within the forward skirt structure. The same access door provides access to components mounted within the forward skirt structure. The same access door provides access to components mounted in the equipment section, which has no access door, and to components mounted on the second-stage motor dome. Air-bleed vent holes are provided to equalize the pressure inside the forward skirt structure to external pressure during launch pressurization, launch, and flight.

EQUIPMENT SECTION STRUCTURE.—The equipment section structurally joins the nose fairing to the forward skirt adapter and provides support and protection for the equipment housed within it. The equipment section structure is made of hardened aluminum alloy, weighs approximately 195 pounds, and it is 25.5 inches long and 72 inches in diameter. Air-bleed vent holes are spaced around the equipment section to provide a means of equalizing interior equipment section pressure and external pressure during launch pressurization, launch, and flight. Cutouts are provided for antennas if the missile is to be used as an evaluation or operational test vehicle. No access doors are provided in the equipment section, but if access is required with the assembled missile, the forward skirt adapter access door can be used. An optical window for guidance subsystem alignment is located at the 0-degree position. The base frame on the forward end of the equipment section contains the support rings to mount the reentry bodies.

NOSE FAIRING STRUCTURE.—The nose fairing structure is secured to the forward end of the equipment section. It encloses the reentry subsystem, provides hydrodynamic and aerodynamic stability, protects components mounted on the base frame, and serves as the prime structural member for hoisting the missile during handling evolutions. The nose fairing, a bullet-shaped laminated-wood shell made of Sitka spruce, weighs approximately 183 pounds and is 91 inches long. It houses two motors that are used to jettison it away from the equipment section and out of the flight trajectory.

Reentry Subsystem

The reentry subsystem consists of multiple Mk 3 Mod 0 reentry bodies, separation and ejection mechanisms, and cabling. The reentry bodies are attached to support rings that are mounted to the equipment section base frame. The support rings house the reentry body separation and ejection mechanisms. Interconnecting cabling provides an electrical interface between the reentry bodies and the electrical subsystem. A detailed description of the Mk 3 reentry body is provided in Special Weapons Ordnance Publication (SWOP) W68.76.

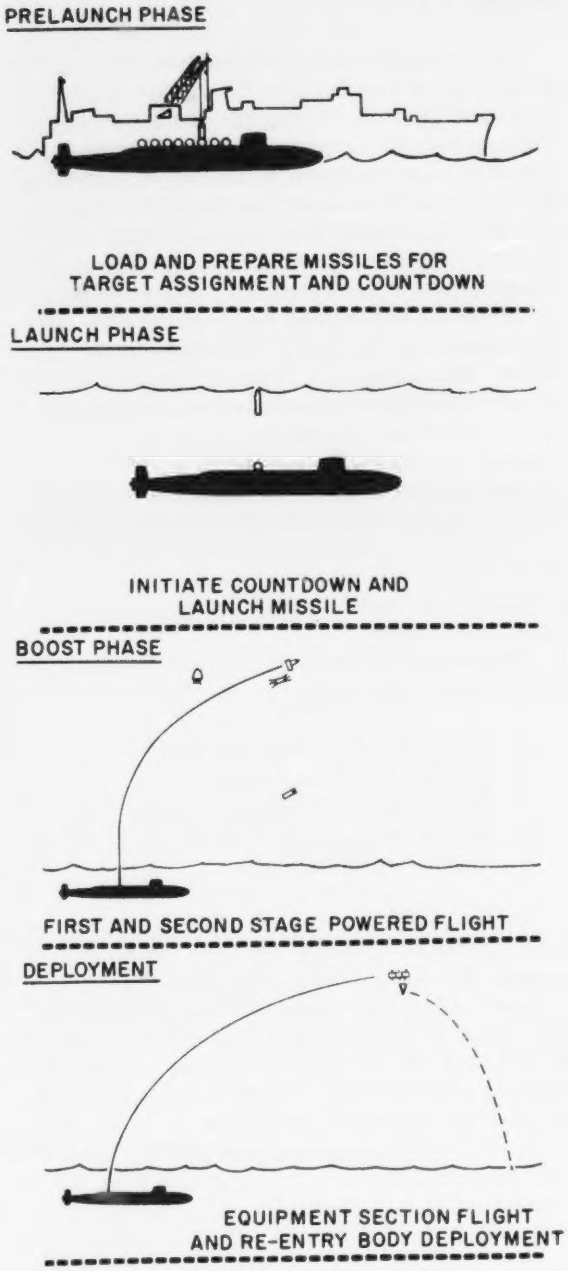
FUNCTIONAL OPERATION

In this final section of the chapter, a typical sequence of events for the operation of the POSEIDON missile system, from the time missiles are loaded onboard the SSBN through the launch and flight of a tactical missile, will be described.

The POSEIDON FBM weapon system operating sequence of events comprises four separate phases that are designated as:

1. Prelaunch
2. Launch
3. Boost
4. Deployment

The four phases are illustrated in figure 7-16.


PRELAUNCH PHASE
LOAD AND PREPARE MISSILES FOR
TARGET ASSIGNMENT AND COUNTDOWN
LAUNCH PHASE
INITIATE COUNTDOWN AND
LAUNCH MISSILE
BOOST PHASE
FIRST AND SECOND STAGE POWERED FLIGHT
DEPLOYMENT
EQUIPMENT SECTION FLIGHT
AND RE-ENTRY BODY DEPLOYMENT

173.296

Figure 7-16.—Phases of operating sequence.

Prelaunch Phase

The prelaunch phase is the period between the onloading of missiles and the launch command from fire control. During the prelaunch phase, the missile is prepared for launch. The guidance subsystem and the electronics battery are installed in the missile as soon as possible after the missile is onloaded and the launcher tube is secured. After the guidance system is installed, weapons system tests are performed to verify the integrity of the missile as well as the other subsystems of the FBM weapon system. As a safety precaution, the ignition inverter is not installed until the submarine is underway.

Preparation of missile launch is normally initiated by the command MAN BATTLE STATIONS MISSILE on the communications circuit. This command orders all ship's personnel to go to their assigned stations and to commence the transition from condition 2SQ, which is a patrol condition, to condition 1SQ, which is the tactical launch condition.

The launch sequence of events is divided into five primary operations:

1. Transition from 2SQ to 1SQ
2. Missile denote sequence
3. Missile assign sequence
4. Missile prepare sequence
5. Missile launch sequence

In the Mk 88 fire control system, the training with guidance (TWIG) mode is selected and spinup of the guidance gimbal assemblies is initiated. After authentication of tactical message and word is passed—SET CONDITION 1SQ FOR STRATEGIC LAUNCH—the tactical fire mode is selected. Once spinup is completed, the missiles are command slewed on a channelized basis. The command slew process rapidly orients the stable platform to the approximate local vertical and launch bearing to reduce the total time of erection and alignment. Before proceeding further, let's also define the meaning of the terms "channelized" and "missilized" as they pertain to the FBM weapons systems. Missilized functions are procedures that are performed on all missiles simultaneously prior to placing the missiles in either of their two firing channels. Once the missiles enter their firing channels, functions become channelized and may only be performed on two missiles simultaneously. You can readily see that the missilized capability saves a considerable amount of time compared to the channelized operations.

Upon hearing the command, MAN BATTLE STATIONS MISSILE, the ship's diving officer (under direction of the conning officer in the ship's control center) brings the ship to its nominal launch depth and controls the ship's speed, trim, and angle parameters, while proceeding to the automatic hovering condition of the submarine. The missile compensation system is also prepared at this time in the ship's control center.

In the missile compartment, the following events are performed during the transition from 2SQ to 1SQ:

1. Missile compartment sea header is lined up, and all launcher tubes are prepressurized.
2. Remote launching condition is selected at the launcher control panel, permitting automatic sequencing of launch events by the missile control center.
3. Hydraulic fluid from the ship's main and vital hydraulic systems is applied to the launcher tubes.
4. The EBW firing units are placed in the "READY" condition.

The transition from 2SQ to 1SQ takes approximately 15 minutes. Once the operations are completed, the fire control supervisor performs a channel check to verify the integrity of the weapon system. If all conditions are normal, the system is considered to be in condition 1SQ. Then the commanding officer will, at his discretion, issue the captain's permission-to-fire signal. With this, the firing mode is selected, and the denote sequence is initiated.

During the missile denote sequence, MTRE Mk 6 Mod 3 activates the missile electronics battery and starts the battery wet-life timer. In the missile compartment, the launch tubes are further pressurized to slightly above sea pressure.

During the missile assign sequence, the Mk 88 fire control system simply verifies that the launcher subsystem and the missile compartment are ready for launch.

During the missile prepare sequence, the Mk 88 fire control system continues to monitor the erection and alignment of the guidance gimbals. The launcher subsystem unlocks the muzzle hatch, and MTRE Mk 6 Mod 3 verifies that the hatch is unseated. MTRE then commands and verifies power transfer to internal, and issues the zero index command to the flight-control subsystem. The fire control system issues intent-to-fire enable, sets reentry system fuzes, and loads trajectory equations into the guidance computer. MTRE issues missile prepared signal to fire control, and launcher issues launcher system ready to fire control. The fire control system then commands missile launch.

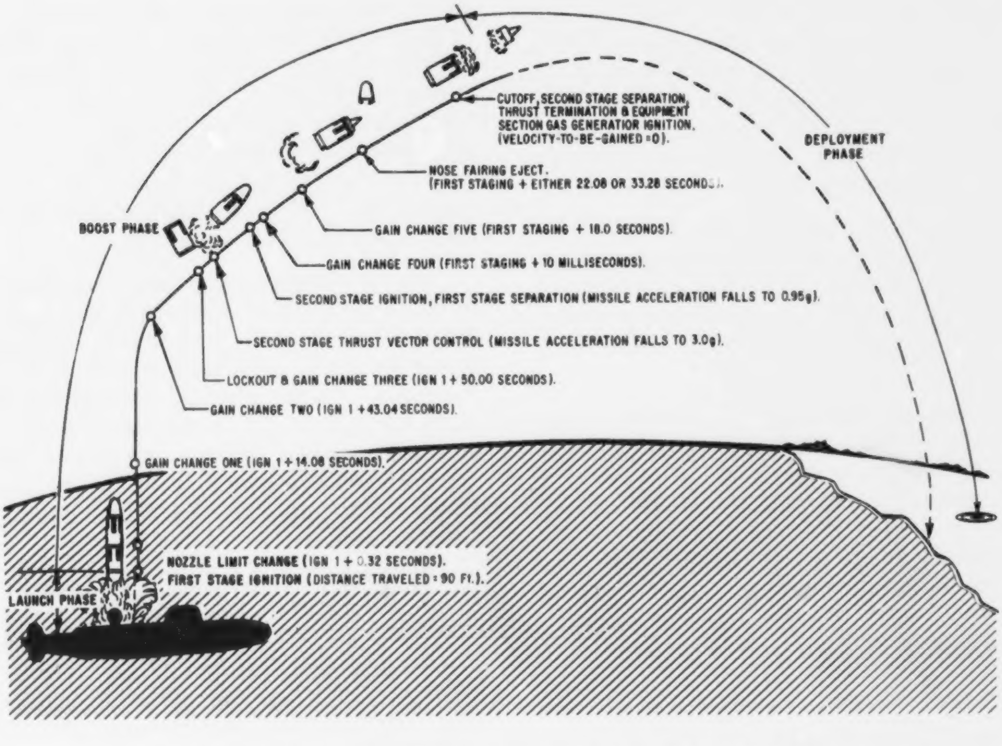
Launch Phase

The launch phase of missile flight is defined as the time between launcher reception of the launch signal from fire control until first-stage motor chamber pressure reaches nominal operating pressure (fig. 7-17). During the launch phase sequence, the launcher ignites the gas generator, and the steam pressure ejects the missile from the launcher tube. After approximately one inch of missile travel, umbilical separation occurs, and the launch-first-motion (LFM) lines are broken, removing the inhibit signal from the interlocks ignition circuits, which include various accelerometers and comparators.

When the missile achieves 3.0 g of acceleration as sensed by interlocks, the first-stage TVC (thrust vector control) gas generator is activated, supplying warm gas to the first-stage hydraulic system components in preparation for first-stage flight. After 46 feet of missile travel, the first-stage ignition firing unit is armed. After 90 feet of missile travel, the ignition 1 fire signal is applied from interlocks to the first-stage ignition firing unit. The flight-control-sequencer-start signal is simultaneously applied to the equipment section flight-control-sequencer-start signal. The launch phase of flight is terminated after the first-stage rocket motor is ignited and the motor chamber pressure reaches nominal operating pressure.

Boost Phase

The boost phase of missile flight (refer to fig. 7-17) is the period of time between the first-stage


CUTOFF, SECOND STAGE SEPARATION, THRUST TERMINATION & EQUIPMENT SECTION GAS GENERATIOR IGNITION. (VELOCITY-TO-BE-GAINED =0).
DEPLOYMENT PHASE
NOSE FAIRING EJECT. (FIRST STAGING + EITHER 22.08 OR 33.28 SECONDS).
BOOST PHASE
GAIN CHANGE FIVE (FIRST STAGING + 18.0 SECONDS).
GAIN CHANGE FOUR (FIRST STAGING + 10 MILLISECONDS).
SECOND STAGE IGNITION, FIRST STAGE SEPARATION (MISSILE ACCELERATION FALLS TO 0.95g).
SECOND STAGE THRUST VECTOR CONTROL (MISSILE ACCELERATION FALLS TO 3.0g).
LOCKOUT & GAIN CHANGE THREE (IGN 1 + 50.00 SECONDS).
GAIN CHANGE TWO (IGN 1 + 43.04 SECONDS).
GAIN CHANGE ONE (IGN 1 + 14.08 SECONDS).
NOZZLE LIMIT CHANGE (IGN 1 + 0.32 SECONDS).
FIRST STAGE IGNITION (DISTANCE TRAVELED = 90 Ft.).
LAUNCH PHASE

33.401

Figure 7-17.—POSEIDON missile boost phase flight trajectory.

rocket motor chamber reaching nominal operating pressure and equipment section RCS gas generator ignition. This encompasses both first and second stages of missile flight.

During the boost phase, the guidance, flight-control, and propulsion subsystems function together to establish the missile flight path. The guidance subsystem computes pointing vectors based on the target data inserted into the guidance subsystem prior to launch. These vectors are continuously computed and are supplied to the flight-control subsystem as digital attitude (P) vector commands in the guidance frame. Flight control converts these digital commands to analog commands in the firing frame and applies the analog commands to the guidance subsystem. When the missile is on the proper flight path, no error signals are issued. The guidance subsystem will issue analog error signals (stable platform gimbal errors) to the flight-control subsystem for any change in the digital attitude commands or deviations in the missile trajectory caused by atmospheric perturbations. The flight-control subsystem converts the electrical error commands into mechanical movement of the first- or second-stage motor nozzle, deflecting the motor thrust and correcting missile attitude. The error commands will decrease to zero when the missile attains the commanded attitude. Missile attitude signals are continuously supplied to the flight-control subsystem. Flight control directs the missile to maintain an acceptable roll attitude.

During first-stage flight, maximum velocity is obtained along the programmed trajectory. First separation and second-stage ignition are initiated as the first-stage motor propellant nears depletion and missile acceleration decreases to less than 0.95 g.

During second-stage flight, the equipment section is boosted near a point in space from which the first reentry body may free-fall to the first target. Second-stage separation and thrust termination are commanded, terminating the forward thrust of the second-stage motor. The equipment section thrusts away from the burning second-stage motor to the point of release.

The following events occur during the boost phase of flight:

1. Nozzle limit change
2. Gain change one
3. Gain change two
4. Gain change three
5. Lockout (LO)
6. Second-stage thrust-vector control activation (TVC 2)
7. First-stage separation (SEP 1) and second-stage ignition (IGN 2)
8. First-stage staging (STG 1)
9. Gain change four
10. Gain change five
11. Nose fairing eject (NFE)
12. Cutoff (CO)
13. Second-stage separation (SEP 2), thrust termination (TT), and equipment section gas generator ignition

Three gain changes, mentioned above, occur during first-stage missile flight, while the last two gain changes occur during second-stage flight. These gain changes are, in effect, alterations to the error commands that originate in the guidance subsystem and are applied to the flight-control subsystem. These alterations are necessary to compensate for decreasing missile weight and a changing center of gravity caused by propellant consumption. Timing signals for the gain changes and the lockout signal, which is discussed below, are initiated by timing circuits in the flight-control sequencer section of the equipment section flight-control electronics package. The timer is started at first-stage ignition (IGN 1) by the flight-control sequencer start command from interlocks.

The first-stage nozzle limit command limits deflection of the first-stage motor nozzle until the motor chamber is fully pressurized. The first-stage motor nozzle is retracted into its housing until the motor reaches nominal operating pressure, when the pressure forces the nozzle into its fully extended position. Limited nozzle deflection in the retracted position prevents possible nozzle damage. The first-stage nozzle limit command is removed at IGN 1 +0.32 second.

The lockout signal (LO) is generated by the equipment section flight-control electronics package at IGN 1 +50.00 seconds. The lockout signal is applied to interlocks, where it enables the application of ac arm signals to the second-stage TVC, first separation, second-stage ignition (IGN 2), nose fairing separation (NFE), and thrust termination (TT) firing units. The LO signal inhibits premature activation of the remaining firing units.

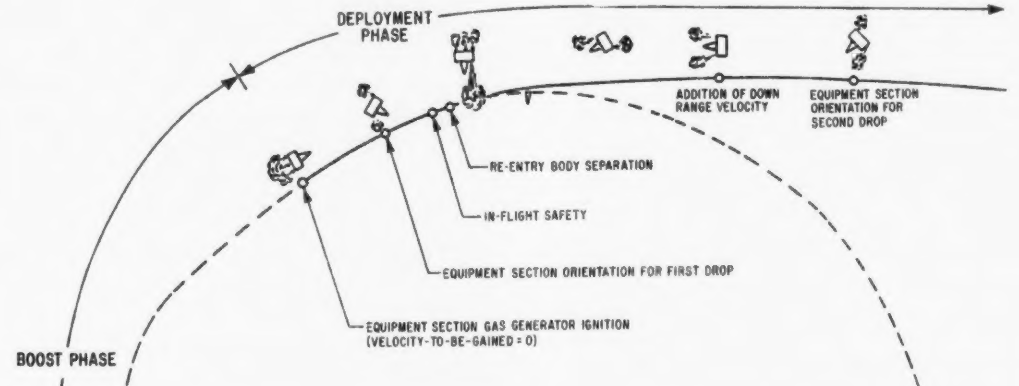
When missile acceleration decreases to 3.0 g, the second-stage TVC gas generator is activated in preparation for second-stage ignition. When missile acceleration continues to decrease to 0.95 g, first-stage separation and second-stage ignition occur simultaneously. Second-stage timing functions are initiated by the first-staging signal when the first stage physically separates from the second stage.

The nose fairing separation event may be programmed at one of two times, providing range flexibility for the various payload configurations. The two times available as options, depending upon the flight-control electronics package flexiplug that is used, are first staging +22.08 seconds and first staging +33.28 seconds. When the NFE firing unit receives the fire signal, it initiates ordnance devices that separate the nose fairing from the equipment section and ignite the two nose fairing jettison motors mounted in the nose fairing. The motors are canted to blast the nose fairing out of the missile flight trajectory.

The cutoff (CO) signal is applied from the guidance electronics assembly to interlocks, where it is used to initiate the second-stage separation, thrust termination, and equipment section RCS gas generator ignition events. The CO signal, from the guidance subsystem, signals that the boost phase of flight has been successful and that the missile has achieved the proper velocity in space. When the CO signal is received, interlocks initiates the blowing out of the thrust termination doors, second-stage separation, and equipment section RCS gas generator ignition. The accomplishment of these three events marks the termination of the boost phase of flight and the initiation of the deployment phase of flight.

Deployment Phase

The deployment phase of flight (fig. 7-18) is the period from cutoff to final reentry body


DEPLOYMENT PHASE
ADDITION OF DOWN RANGE VELOCITY
EQUIPMENT SECTION ORIENTATION FOR SECOND DROP
RE-ENTRY BODY SEPARATION
IN-FLIGHT SAFETY
EQUIPMENT SECTION ORIENTATION FOR FIRST DROP
EQUIPMENT SECTION GAS GENERATOR IGNITION (VELOCITY-TO-BE-GAINED = 0)
BOOST PHASE
LAUNCH PHASE

33.402

Figure 7-18.—Deployment phase sequence of events.

deployment. During the deployment phase of flight, the equipment section reaction-control system maneuvers the loaded equipment section into position for each reentry body deployment event.

Equipment section steering is similar to steering in the boost phase. Pointing (P) vectors are issued by the guidance computer, and the propulsive force for attitude control is supplied by the gas generator. In addition, digital force (F) vectors are issued by the guidance computer to control equipment section velocities. The P and F vectors direct the equipment section to a point in space where an RB will free-fall to a selected target. The RCS of the flight-control subsystem provides the thrust so that the equipment section can be maneuvered to satisfy the P and F vectors for RB release. Two modes of flight, coarse and vernier, are used for each RB release. These modes are controlled by the vernier mode initiate (VMI) signal from the guidance subsystem and by the reset signal from the flight-control subsystem.

The guidance subsystem issued the in-flight safety (IFS) signal when the equipment section velocity approached the required velocity. The IFS is routed to interlocks, which issues the dc and ac arming signals to enable the RBs firing units. The guidance subsystem issues the VMI signal to shift to the vernier mode of flight when the velocities to be gained are less than zero. In the vernier mode, the equipment section is precisely maneuvered to orient it for RB release. The flight-control subsystem issues the release signal to interlocks, which routes a fire signal to the firing unit of the RB selected for release. The firing unit initiates release of the RB. Simultaneously, with the release signal, interlocks applies a safe-to-arm signal (STAS) to the reentry subsystem to arm the selected RB. After each release, the flight-control subsystem applies a reset signal to the guidance subsystem to start the sequence for the next RB release. The sequence is repeated until all the RBs are released.

The deployment phase of missile flight occurs in the following sequence:

1. Clearance Mode
2. Coarse Mode
3. Vernier Mode
    - a. Null Submode
    - b. Release Submode
    - c. Backup 1 Submode
    - d. Backup 2 Submode
4. Repeat the coarse and vernier modes for the remaining RBs
5. Equipment section flyaway

CLEARANCE MODE.—The purpose of the clearance mode is to ensure that the equipment section has a smooth flight away from the second stage. Shortly before second-stage cutoff, the guidance subsystem issued the vernier-mode bypass (VMB) signal to the flight-control subsystem sequencer section. At second separation, the guidance computer issues the vernier-mode initiate (VMI) to the flight-control subsystem sequencer section and the cutoff signal to interlocks. The VMB and VMI signals condition the flight-control subsystem for clearance mode flight.

Approximately 51.5 milliseconds after cutoff, the second-stage separation cable disconnects, starting the flight-control sequencer timer. The four type A thruster valves are simultaneously commanded to produce maximum forward thrust so that equipment section stability will not be affected by the turbulence of the second-stage motor thrust termination. Full forward thrust is continued for 3.04 seconds. At this time, the ES FCEP sequencer section issued the first reset signal to the guidance computer, requesting the removal of the VMB and VMI signals. The removal of these two signals shifts the equipment section into the coarse mode of flight.

COARSE MODE.—The guidance computer issues new P and F vectors to initiate the first coarse mode of flight. The P vector commands produce pitch and yaw commands in the same manner as they did in the boost phase. The digital P vector commands are converted to an analog form in the ES FCEP and then applied to the guidance gimbal assembly. There they are converted from the firing reference frame to the missile frame. These commands now control the four type A thrusters in various combinations to effect the equipment section pitch and yaw.

The digital F vector commands control the velocity of the equipment section. Digital-to-analog conversion and reference frame conversion of the F commands are the same as the P vector conversion. The F vector analog commands are phase multiplexed with the P vector analog commands in the ES FCEP. The combined command signal is applied to the guidance gimbal assembly for conversion to the missile frame. The combined missile frame pointing and force error commands are routed to the ES FCEP, where they are demodulated into the P and F components. The F command components control the four type A thrusters (Fx component) and the four type B thrusters (Fy and Fz components).

Controlled thrust continues while the equipment velocity-to-be-gained is driven toward zero. When the velocity-to-be-gained is less than 16 feet per second, the guidance computer issues the IFS signal to enable the RB release firing unit. When the velocity-to-be-gained passes zero, (no more acceleration required), the guidance computer issues the VMI signal to initiate the vernier mode.

VERNIER MODE.—The vernier mode is divided into four submodes, which occur in the following sequence.

Null Submode.—During the null submode, the equipment section is reoriented for RB deployment. The force vector channel sensitivity is increased to achieve precise velocity control. Bias voltages are added to the guidance commands by the flight-control subsystem to compensate for the tilt angle of the RB and for the gas effects on the RB after release. The tilt angle is measured between the center lines of the equipment section and the RB. When the force, attitude, and rate signals are all driven to zero, a null condition is achieved and the release submode is initiated. If a null condition is not achieved, a null override signal from flight control will cause the RB to be released 12.5 seconds after the VMI signal was issued.

Release Submode.—If the null condition persists for approximately 100 milliseconds or the null override signal is present, the release signal is issued from the flight-control subsystem, and the RB is deployed. During the release submode, the equipment section is precisely maintained for 130 milliseconds. The STAS signal is supplied by interlocks to the reentry subsystem simultaneously with RB separation.

Backup Submode.—Following the 130-millisecond release period, type A thruster reverse is commanded to back the equipment section away from the release RB. Total backup time is a variable and controlled by the flight-control subsystem to provide fixed spacing between the equipment section and the released reentry body. Backup is divided into two submodes: backup 1 and backup 2. For the first 510 milliseconds, backup 1, the equipment section attitude is maintained at the RB released attitude. The flight-control subsystem alignment biases, which compensate for the RB tilt angle, are then removed. During backup 2, the equipment section backs away from the released RB with the center line aligned with the P vector. After up to two seconds of backup, the flight-control subsystem issues the reset signal to the guidance computer, requesting the VMI removal and new P and F vectors. When the VMI is removed, the second coarse mode begins. The equipment section reorients with the RBs facing aft and then thrusts to the next drop area.

REMAINING REENTRY BODY RELEASES.—Following each RB release, the flight-control subsystem applies a reset signal to start a new release-position calculation by guidance. The coarse mode continues until the velocity-to-be-gained is again less than zero. The guidance computer issues the second VMI and the vernier mode is repeated. The coarse and vernier modes are repeated until all RBs have been deployed.

EQUIPMENT SECTION FLY AWAY.—After the last RB has been ejected, the equipment section will thrust to a preprogrammed point, enter the vernier mode and remain in this mode until all the fuel is expended. The equipment section then follows a ballistic trajectory into the Earth's atmosphere.

Operation of the POSEIDON missile has been basically described. Since we only skimmed the surface of the technical information on this missile, we suggest that you refer to the technical OPs for detailed information. For the POSEIDON missile, refer to NAVORD OP 3662 and OP 3663, volume 1, parts 1 and 2.

MISSILE LAUNCHING SYSTEM

This section will describe the operation of the launching system as it relates to the FCS, so that you will be able to follow the sequence of events up to and including the missile away signal.

The Missile Technicians are responsible for the maintenance of the missile launching system (MLS). We are interested in the interface between the MLS and the FCS. Control of the MLS and some associated ship system equipment is performed locally or remotely. When under local control, (during loading, cruising, training, and missile jettisoning), all operations are manually initiated at the launcher control panel. When under remote control, (during a missile launch, tactical mode), the launcher control panel automatically initiates various operations upon receipt of commands from FC. The MLS accomplishes the ordered task and reports its status to FC. Therefore, a functional description of the MLS sequence of operation in the tactical mode is included in this manual.

The MLS provides for missile stowage, protection, and ejection. The 16 missiles are individually stowed and protected for extended patrol periods. The missiles are ejected on command, while the submarine is surfaced or submerged. Missile ejection is accomplished by the application of a high-pressure gas mixture to the base of the missile. The missile is launched by a controlled buildup of pressure beneath the missile, causing it to rise smoothly out of the launcher tube. This results in a flameless missile launch with first-stage rocket motor ignition occurring a safe height above the submarine.

MK 24 LAUNCHING SYSTEM (POSEIDON)

The Mk 24 launching system is installed on board some 616, 627, and 640 class FBM submarines in support of the POSEIDON missile. The launching system stows, protects, and is capable of launching 16 POSEIDON missiles during a surface or submerged launch. Each missile is resiliently mounted in the launcher tube to prevent shock and vibration damage. Missile tube functions during prelaunch, launch, and post launch operations are controlled and monitored by the launching system. Fail-safe devices prevent inadvertent launching of the missiles. Missile launch is accomplished by controlled release of a mixture of gas, steam, and water into the eject chamber beneath the missile. As previously stated, this results in a flameless missile launch, with first-stage rocket motor ignition occurring at a safe height above the submarine.

The Mk 24 launching system, located in the missile compartment, consists of Missile Launcher Tube Mk 12 Mod 0, Missile Support Group Mk 2 Mod 0, Umbilical Retractors Mk 1 and Mk 2, Missile Launcher Control Group Mk 18 Mod 2, and Missile Ejector Group Mk 8 Mod 0. Figures 7-19, 7-20, and 7-21 illustrate the components of the Mk 24 launching system and their location.

Missile Launcher Tube Mk 12 Mod 0

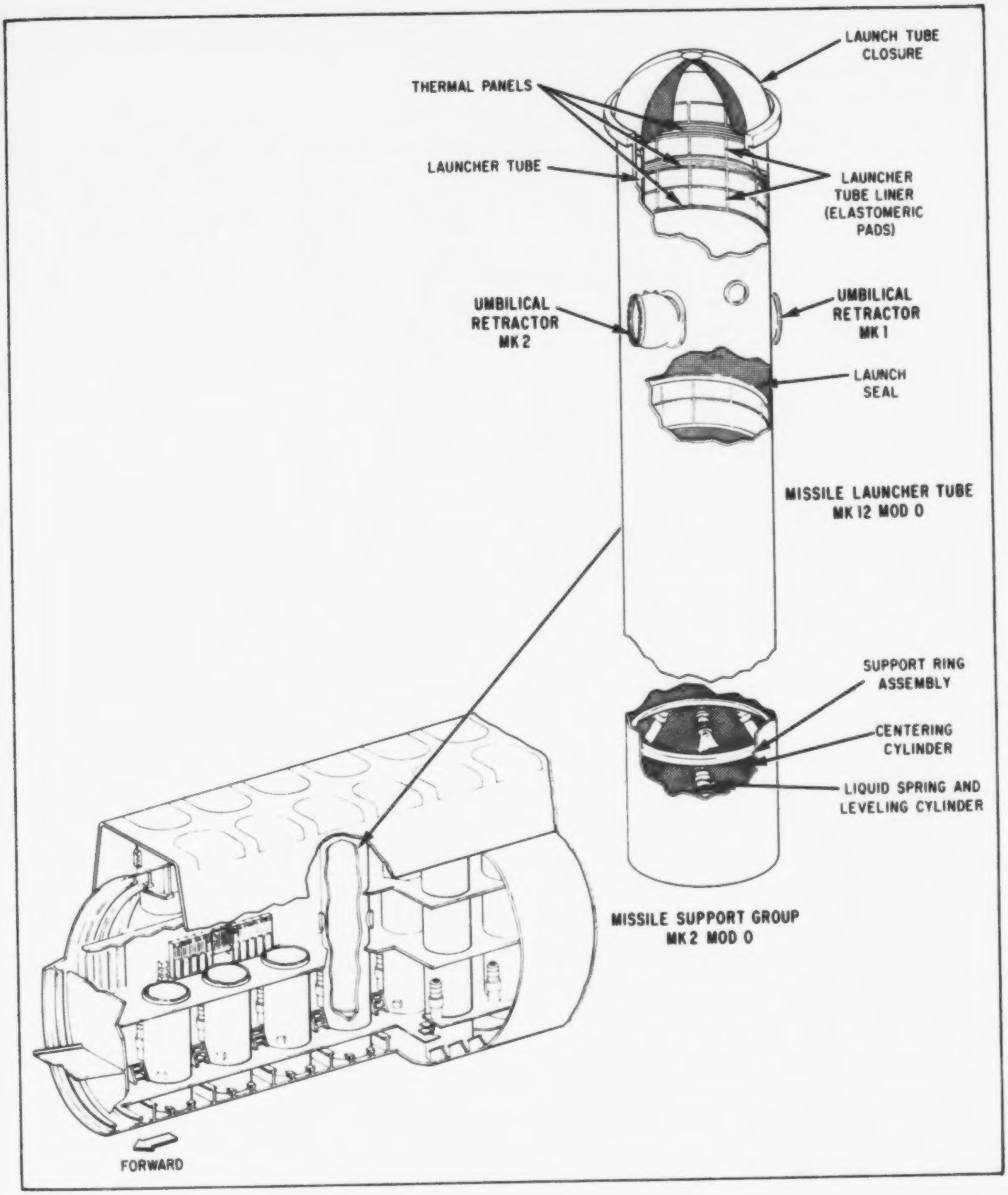
The missile launcher tube provides storage and servicing facilities for the missile during patrol and missile support during launch. Each launcher tube is installed within an outer tube. Watertight access doors in the outer tube open to penetrations in the launcher tube to provide access to the missile. Passages between the launcher and outer tubes are sealed by interface seals, and the space between the two tubes is filled by a polyurethane foam (grouting) filler. The major components of each missile launcher tube are a launcher tube assembly and a launcher tube closure.

LAUNCHER TUBE ASSEMBLY.—The launcher tube assembly provides lateral support and shock protection for the missile during storage and ejection. The assembly consists of a launcher tube, a launcher tube liner, launch seals, and thermal panels.

The launcher tube itself is 29 feet 6 inches long and has a 77-inch inside diameter. The tube has 15 penetrations-access doors, electrical and pressurization connections, umbilical retractors, and optical viewing windows.

The launcher tube liner consists of elastomeric pads (refer to fig. 7-19) bonded to the launcher tube. These pads, coated with a nonstick coating to reduce friction with the missile, provide both lateral support and shock protection for the missile.

Six launch seals positioned at various levels around the launcher tube and adjacent to the liner pads, limit the launch pressures on the missile


LAUNCH TUBE CLOSURE
THERMAL PANELS
LAUNCHER TUBE
LAUNCHER TUBE LINER (ELASTOMERIC PADS)
UMBILICAL RETRACTOR MK 2
UMBILICAL RETRACTOR MK 1
LAUNCH SEAL
MISSILE LAUNCHER TUBE MK 12 MOD 0
SUPPORT RING ASSEMBLY
CENTERING CYLINDER
LIQUID SPRING AND LEVELING CYLINDER
MISSILE SUPPORT GROUP MK 2 MOD 0
FORWARD

33.468

Figure 7-19.—Missile launcher tube, support group, and umbilical retractors.

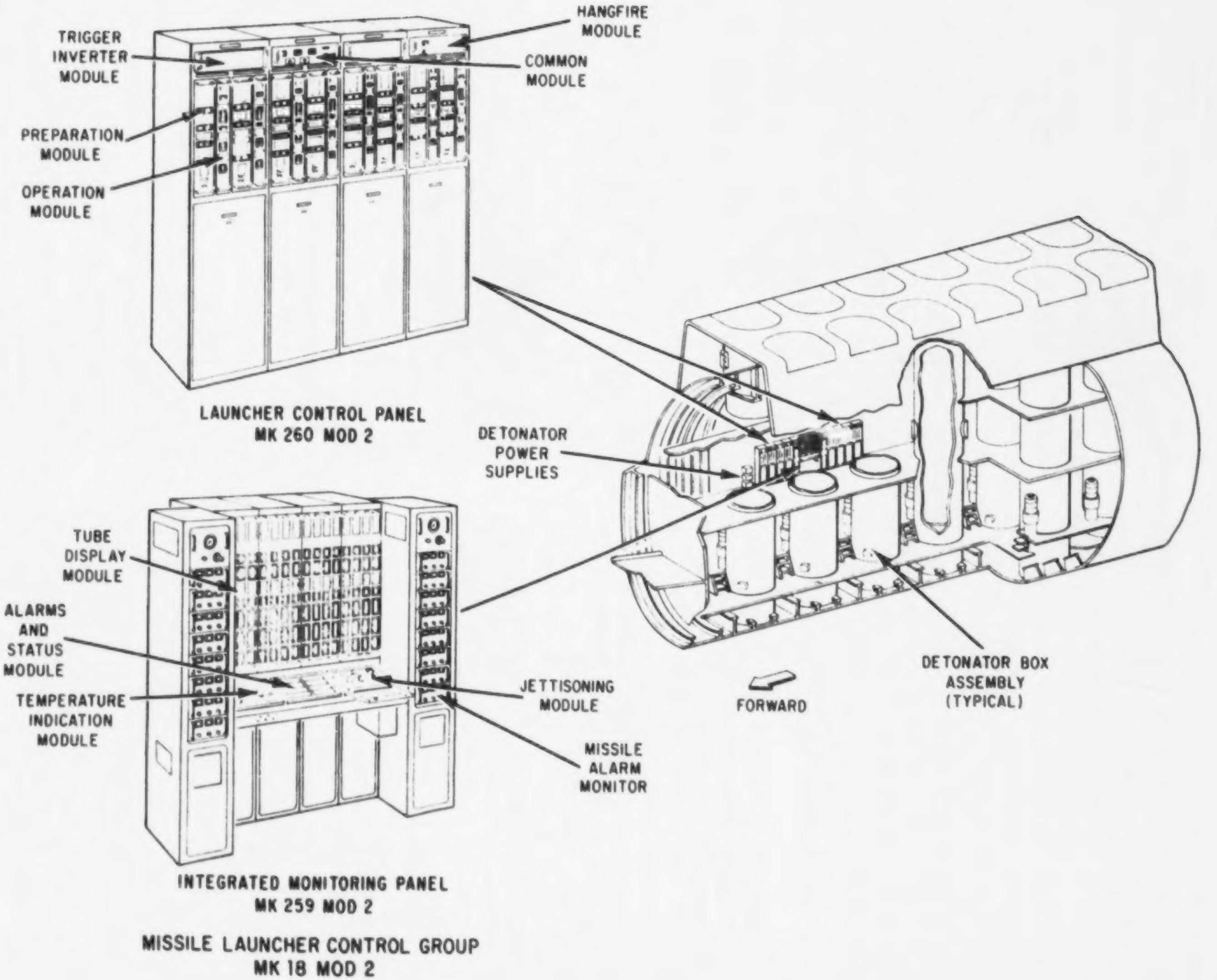
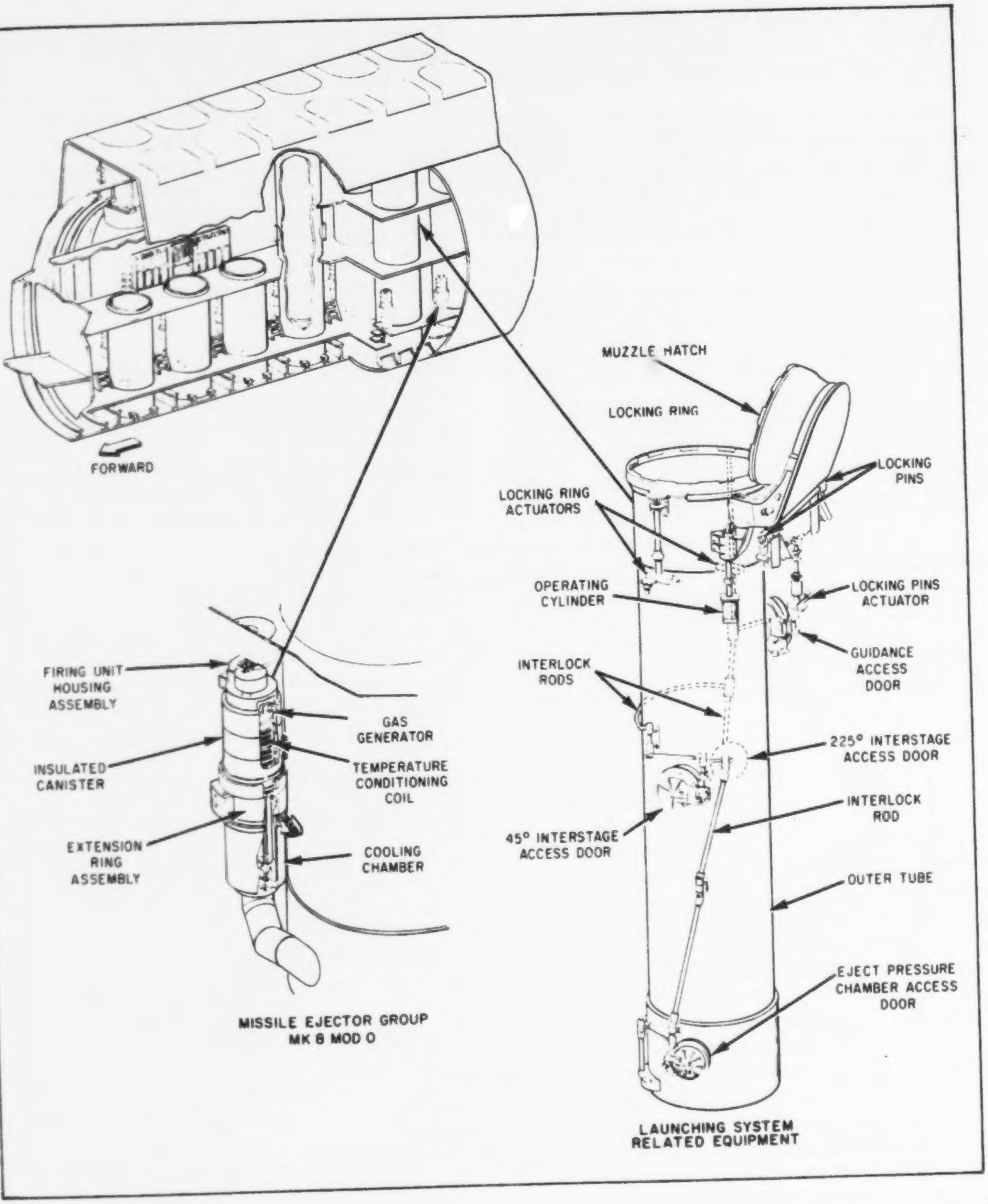

TRIGGER INVERTER MODULE
PREPARATION MODULE
OPERATION MODULE
HANGFIRE MODULE
COMMON MODULE
LAUNCHER CONTROL PANEL MK 260 MOD 2
DETONATOR POWER SUPPLIES
TUBE DISPLAY MODULE
ALARMS AND STATUS MODULE
TEMPERATURE INDICATION MODULE
JETTISONING MODULE
MISSILE ALARM MONITOR
FORWARD
DETONATOR BOX ASSEMBLY (TYPICAL)
INTEGRATED MONITORING PANEL MK 259 MOD 2
MISSILE LAUNCHER CONTROL GROUP MK 18 MOD 2

Figure 7-20.—Missile launcher control group.

33.469


FORWARD
MUZZLE HATCH
LOCKING RING
LOCKING PINS
LOCKING RING ACTUATORS
OPERATING CYLINDER
LOCKING PINS ACTUATOR
GUIDANCE ACCESS DOOR
INTERLOCK RODS
FIRING UNIT HOUSING ASSEMBLY
GAS GENERATOR
INSULATED CANISTER
TEMPERATURE CONDITIONING COIL
225° INTERSTAGE ACCESS DOOR
INTERLOCK ROD
EXTENSION RING ASSEMBLY
COOLING CHAMBER
45° INTERSTAGE ACCESS DOOR
OUTER TUBE
EJECT PRESSURE CHAMBER ACCESS DOOR
MISSILE EJECTOR GROUP MK 8 MOD 0
LAUNCHING SYSTEM RELATED EQUIPMENT

33.470

Figure 7-21.—Missile ejector group and missile launching system related equipment.

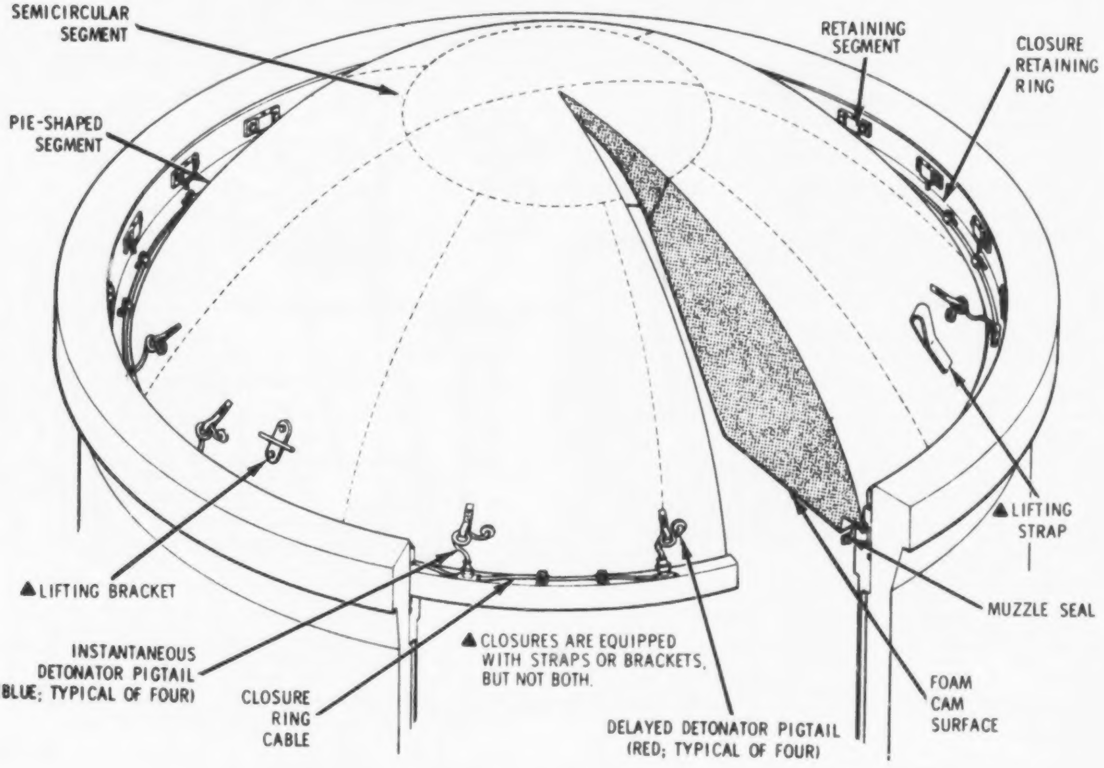
skin to an acceptable level during launch. The surface that touches the missile skin is also coated with the same nonstick coating manufactured by Dupont.

Three sets of stainless steel circumferential bands (thermal panels) of heat transfer elements maintain ambient temperature at the forward end of the missile by circulating heating or cooling water as necessary from the missile heating and cooling system.

LAUNCHER TUBE CLOSURE.—The launcher tube closure seals the launcher tube from outside environment when the muzzle hatch is open. The closure is divided into 10 segments. At missile launch, a shaped explosive charge system arranged on the closure is detonated, and the closure is separated into eight pie-shaped and two semicircular pieces (fig. 7-22). Rupture of the closure must occur to permit exit of the missile without damage and without having the missile trajectory affected by the closure. Detonation of the explosive charge is initiated at missile first motion by departure switches on the support ring. Eight detonators, four instantaneous and four delayed, detonate the explosive charge. The instantaneous detonation causes the separation of the closure dome from the launcher tube as well as the separation of the two semicircular pieces at the top of the closure. The delayed detonation, milliseconds later, causes the eight pie-shaped segments to separate.

Missile Support Group Mk 2 Mod 0

The missile group maintains the missile concentric with the launcher tube, prevents additional missile misalignment in the launcher tube, and provides vertical shock protection for the missile. The support group is installed in the


SEMICIRCULAR SEGMENT
PIE-SHAPED SEGMENT
RETAINING SEGMENT
CLOSURE RETAINING RING
▲LIFTING STRAP
MUZZLE SEAL
▲LIFTING BRACKET
INSTANTANEOUS DETONATOR PIGTAIL (BLUE; TYPICAL OF FOUR)
CLOSURE RING CABLE
▲CLOSURES ARE EQUIPPED WITH STRAPS OR BRACKETS, BUT NOT BOTH.
DELAYED DETONATOR PIGTAIL (RED; TYPICAL OF FOUR)
FOAM CAM SURFACE

33.471

Figure 7-22.—Launcher tube closure.

eject pressure chamber and consists of four liquid spring and leveling cylinder (LSLC) assemblies, four centering cylinders, and a missile support ring assembly (refer to fig. 7-19).

LIQUID SPRING AND LEVELING CYLINDER ASSEMBLIES.—The liquid spring and leveling cylinder assemblies provide equally divided vertical support for the missile. Each LSLC assembly has two separate functions. The liquid spring occupies the upper end of the cylinder and provides vertical support and shock mitigation for the missile. The leveling cylinder occupies the lower end of the cylinder and adjusts the support ring horizontal plane to conform to the missile skirt during procedures. After the missile is loaded into the tube, the leveling cylinder, connected between the support ring and the ship's hull, is locked in place.

CENTERING CYLINDERS.—Four cylinders (refer to fig. 7-19) maintain the support ring concentric with the launcher tube when a missile is not installed. Each cylinder is connected between the support ring and the wall of the eject pressure chamber. After missile installation, the cylinders extend or retract as necessary without interfering with the movement of the support ring.

SUPPORT RING ASSEMBLY.—The support ring assembly (refer to fig. 7-19) vertically supports and ensures azimuthal alignment of the stowed missile, provides missile away or in-place indications, provides humidity status indications and initiates detonation of the launcher tube closure explosive charge. The assembly consists of the support ring, two departure switch assemblies, an antirotation key, and associated electrical installations.

The support ring provides a seat for the missile and a mounting surface for the components of the support ring assembly. During loading, the missile is guided onto the seating surface by a lip on top of the support ring. The leveling system compensates for any misalignment between the missile skirt and the support ring. The support ring also contains detectors for monitoring lower zone temperature and humidity. Each departure switch assembly actually contains two switches, one for indications and the other for closure detonation. When a missile is seated on the support ring, the switch plunger is depressed, providing an indication that the missile is in place. At missile first motion, the missile lifts off the support ring and releases the switch plungers, initiating detonation of the closure and providing an indication of missile away. The two departure switch assemblies are redundant for fail-safe operation. The antirotation key is installed by the lower-level missile handling team in a slot through the support ring at 37 degrees azimuth to prevent missile rotation after onloading and final azimuth alignment is completed.

Umbilical Retractors Mk 1 and Mk 2

The umbilical retractors (refer to fig. 7-19) withdraw the umbilical plugs from the missile at launch. When missile first motion occurs, the umbilical plugs are disconnected through cam action initiated by the upward travel of the missile. After initial disconnect from the missile, the umbilical plugs are retracted and locked into place by a gas-operated piston assembly. Gas pressure for the retract mechanisms is available from an eject entry pipe pressure tap. Umbilical Retractor Mk 1 is located at 45 degrees azimuth, and Umbilical Retractor Mk 2 is located at 310 degrees azimuth.

Missile Launcher Control Group Mk 18 Mod 2

The missile launcher control group controls and monitors the launching system during loading, cruising, launching, and jettisoning operations. The control group (refer to fig. 7-20) consists of two Launcher Control Panels (LCPs) Mk 260 Mod 2, one Integrated Monitoring Panel (IMP) Mk 259 Mod 2, 16 EBW firing units, three detonator power supplies (two active, one spare), and 16 detonator box assemblies.

In looking over the main components of the launcher control group of the Mk 24 launching system, we can see that there is an integrated monitoring panel and circuitry associated with the closure detonation network. Before proceeding to the actual operation of this control group, let's look at the association of the technician with this complex portion of the Mk 24 launching system.

The central portion of the launcher control group (two LCPs and IMP) is located in the middle-level missile compartment. This area is continuously manned underway or in port and is designated as the launch operation station (LOS) watch. There is also an assistant (ALOS) continuously available to the LOS underway, as needed, and a roving patrol, who monitors the entire missile compartment underway and in port. The LOS is continuously monitoring the status of the missiles, missile tubes, firing units, muzzle hatches, valve lineups, and hydraulic and pneumatic operating pressures using IMP and the two LCPs. Corrective action is taken as necessary. During a tactical launch, the monitoring and operation of the launcher central area are carried out by four or more personnel.

There are various colors of indications on the LCPs and IMP with which you should be familiar. The colors of the indications and their meanings are as follows:

1. Blue—Command
2. Green—Condition safe for launching or cruising
3. Red—Malfunction or condition requiring corrective action
4. White—Static condition or action complete
5. Amber—Condition requiring monitoring

Each indicator light has two lamps for reliability. For ease of replacement, the lampholders are pivoted to rotate out from the modules.

LAUNCHER CONTROL PANEL MK 260 MOD 2.—The launcher control panels (LCP 1 for missiles 1-8 and LCP 2 for missiles 9-16) provide control and monitoring of the launching system operations and missile tube pressurization and provide the interface between the launching and fire control systems. Each LCP consists of one common module, eight preparation modules, eight operation modules, one hangfire module, and two trigger/inverter modules (TIM).

The common module enables selection of launch mode and pressurization supply and displays status conditions common to the entire launching system. The launch mode switch allows the selection of SURFACE or SUBMERGED launch. SUBMERGED position on one common module will override SURFACED position on the other common module. The pressurization supply switch allows the selection of NITROGEN or AIR for pressurizing launcher and supplying control gas for the breather valve (NITROGEN will normally be selected for a tactical launch). NITROGEN position on one common module will override AIR position on the other common module. Indications on the common module and their meanings are as follows:

1. POWER ON—Power is available at the LCP
2. LCC MODE SW. NORMAL—Fire control circuits are connected to launcher and the missile compartment
3. AIR—Air supply isolation valve is positioned for pressurizing with air
4. NITROGEN—Nitrogen supply isolation valve is positioned for pressurizing with nitrogen
5. NITROGEN SUPPLY LOW—Pressure in nitrogen bank has dropped to 1000 ± 50 psig. (Pressure has to increase to 1200 ± 50 psig to clear alarm.)

The trigger inverter module (TIM) develops and distributes charge and trigger signals to an associated gas pressure generator EBW firing unit. Each TIM (two on each LCP) contains four trigger/inverter units. Each unit charges a firing capacitor and triggers a gap switch in the EBW firing unit that releases the charge, firing the EBW initiator.

The hangfire module monitors for a hangfire condition that causes a system hold to be generated and displayed. A hangfire condition occurs when a missile away signal is not indicated on the LCP within one second after the EBW initiator receives the firing pulse. A switch is provided to release the system hold on all launchers except the affected one. A SYSTEM HOLD indication is also displayed on the module, the affected missiles at the Fire Control Console, and the Attack Center Indicator Panel (ACIP).

The preparation modules (eight on each LCP) control access to the missile tubes and monitor the preparation functions of missile launch. Switches control the operation of the mechanical interlocks that permit access to the missile tube and the selection of the mode of breather valve operation. Indicators display the status of the access doors, missile tube pressurization, and the ejector group equipment.

The operation modules (eight on each LCP) enable selection of local or remote control of the missile tube denote sequence and muzzle hatch (MH) operation; display missile tube pressurization, MH operation, and missile away status; and control the generation of hold commands to halt missile launch preparation for its associated missile tube.

INTEGRATED MONITORING PANEL MK 259 MOD 2.—The integrated monitoring panel monitors and displays the status of critical missile and launcher tube circuits, generates an MC (missile compartment) hold for certain critical conditions, and permits local control for emergency missile jettisoning. The panel consists of 16 tube display modules, a temperature indication module, an alarms and status module, a jettisoning module, and the missile alarm monitor. This panel is the central monitoring station for the LOS watchstander of the Mk 24 system.

The tube display module monitors and displays the status of critical circuits for one launcher tube and its associated missile, as well as the status of the missile in the launch sequence. On the tube display module, there are actuator/indicators (A/I's). This indicator also contains a push-type switch which, when depressed by the LOS watchstander, activates other circuits in the launcher.

The temperature indication module monitors launcher tube air and its associated missile and operating conditions common to all tubes. The module contains an A/I for each tube and A/I's and indicators for conditions common to all tubes. When an abnormal condition affects the missile or tube, its associated A/I will light red, and an audible alarm will sound. Depressing the A/I displays the condition at the tube display module, silences the alarm, and changes the indication to amber.

The jettisoning module provides the capability for emergency missile jettisoning. The module front panel is protected by a key-locked cover. When the cover is opened by a sensitive key (special handling and custodial requirements), a ship's alarm is sounded. Opening the cover permits access to switches that enable selection and initiate ejection of the missile. Jettisoning will only be carried out in an extreme emergency by the weapons officer in strict compliance with applicable weapons operating procedures.

The missile alarm monitor (MAM) monitors for the correct configuration of missile ignition inverter installation. The Missile Technicians install the ignition inverters for the 1SQ and 2SQ conditions and remove them for the 3SQ and 4SQ conditions. The monitor consists of two cabinets (refer to fig. 7-20), a left-hand cabinet that monitors missile 1 through 8, and a right-hand cabinet that monitors missiles 9-16.

DETONATOR POWER SUPPLIES.—The detonator power supplies (refer to fig. 7-20) convert 450-volt ac 60-Hz power to 50-volt dc for distribution to the 16 detonator box assemblies. Two of the supplies are active, and one is a spare. The spare, if needed, must be wired or patched into the system.

DETONATOR BOX ASSEMBLIES.—The detonator box assemblies (refer to fig. 7-20) provide the circuitry required to deliver power from the detonator power supplies to the departure switches for subsequent distribution to the launcher tube closure detonators. This group consists of 16 assemblies, one mounted on each outer tube in the lower-level missile compartment.

EXPLODING BRIDGEWIRE FIRING UNIT.—The exploding bridgewire (EBW) firing unit stores and releases the 2250 ± 250-volt dc charge necessary to fire the EBW initiator in its associated gas generator. The EBW firing unit is enclosed within the EBW firing unit housing assembly (refer to fig. 7-21). The unit is made ready by lower-level technicians who position it from the SAFE to the READY position using a sensitive key. The position of the switch is monitored continuously on the preparation module of the LCPs.

MISSILE EJECTOR GROUP MK 8 MOD 0.—The missile ejector group systems Mk 24 uses a pressurized mixture of gas, steam, and water to launch the missile. This gas, steam, and water system of the Mk 24 ejects the missile with a uniform pressurization rate. The missile ejector group is made up of a firing unit housing assembly, a Propellant-Actuated Gas Pressure Mk 50 Mod 0, a cooling chamber, and an insulated canister (refer to fig. 7-21).

The gas generator is a solid-propellant chamber mounted vertically atop the cooling chamber assembly. At launch, the gas generator is ignited, creating a rapid buildup of pressure within the cooling chamber. As a result of this pressure, water is forced out of the cooling chamber, through a series of metering holes in a standpipe traversing the length of the cooling chamber. Hot gases, exhausting at a programmed rate from the gas generator, pass through the standpipe, where they are mixed with the water from the cooling chamber. This lowers the temperature of the gases, thus averting the danger of premature missile ignition. The resultant mixture of gas, water, and steam passes through a ruptured water closure, through the launch gas entry pipe into the eject pressure chamber to launch the missile. Fail-safe devices and circuits prevent inadvertent launching of the missile.

The gas generator is ignited by an exploding bridgewire (EBW), which converts an electrical command into an explosive impulse. The EBW firing unit receives the launch command from the fire control system through the launcher control panel. This command could also come from the jettison control panel during emergency conditions. A key obtained from the commanding officer is used just prior to launch to switch the EBW firing unit from the SAFE to the READY position by lower-level technicians. Another key, the EBW housing ring key, locks the EBW firing unit under a housing ring and prevents any tampering with the firing unit. Another safety precaution is the continuous monitoring of the ejector water level at the launcher control station prior to launch.

Related Equipment

Also illustrated in figure 7-21 are various related equipment of the Mk 24 launching system, such as the outer tube, access doors, and the interlock rods. These mechanical interlocks safeguard against flooding of the missile compartment by preventing simultaneous opening of the access doors and the muzzle hatch or the compensating sea valve. Rods are locked in place and prevented from rotating by a solenoid-actuated locking pin controlled at the LCP. Also of some interest in the illustration are the locking pin and locking ring mechanisms of the muzzle hatch.

Pressurization System

Before concluding the discussion of the Mk 24 launching system by briefly describing its functional operation, there is one other important subject that should be covered. This is the missile pressurization system shown in figure 7-23. The pressurization system pressurizes and maintains the missile tube to a positive differential pressure above sea pressure during a submerged launch. Pressurizing the missile tube prior to a launch pressurizes the interior of the missile through various breathe holes. This enables the missile to withstand the sea environment after the missile is ejected from the tube. In addition, pressurization aids in opening the muzzle hatch against sea pressure and supports the missile tube diaphragm after the muzzle hatch is opened.

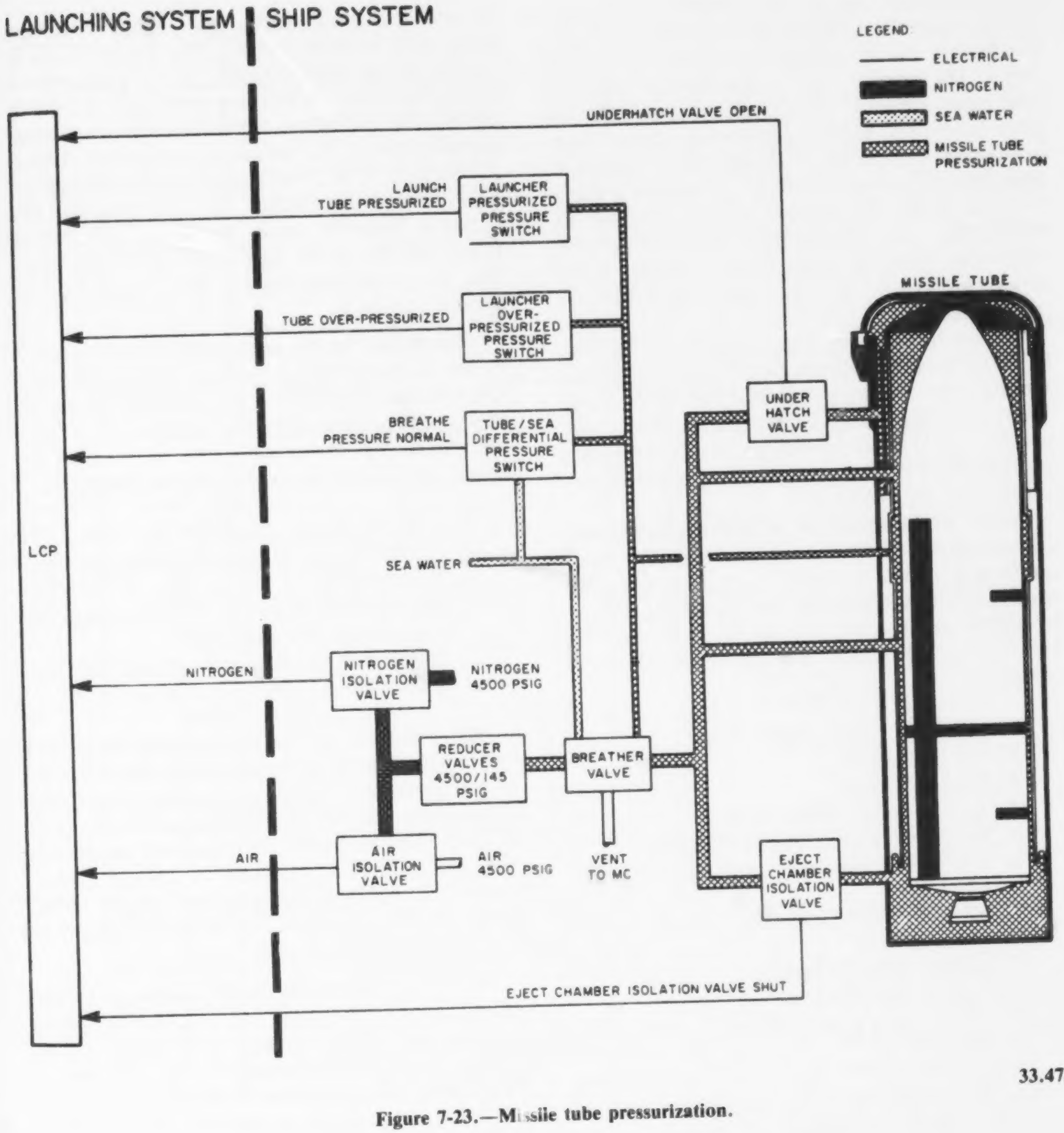
The pressurizing agent, selected at the LCP common module, is either nitrogen or air. The nitrogen or air is supplied from the missile gas system. Air is used for pressurization during training missile launching operations of the Mk 24 system. Nitrogen is used with the Mk 24 systems during tactical missile launching operations because of its inerting capabilities on the hot gases of the expended gas generators.

A breather valve in the pressurization system controls the flow of air or nitrogen into and out of the missile tube. Each missile is equipped with two breather valves (one active, one on standby). In the event of an active breather valve failure, the standby breather valve has to be manually shifted into operation by the technician. The breather valve can be operated in three different manners: (1) manually at the breather valve, (2) remotely from the LCP, or (3) automatically.

BREATHER VALVE.—Breather valve operation maintains the desired pressure in the missile tube. As stated above, the breather valve can be operated in one of three separate modes: automatic, remote, and manual. For a tactical launch, the automatic mode is selected. However, various casualty situations could develop that would lead to operation of the breather valve in one of the other modes.

MK 24 Functional Operation

When the commanding officer (CO) issues the command, MAN BATTLE STATIONS


LAUNCHING SYSTEM
SHIP SYSTEM
LEGEND
ELECTRICAL
NITROGEN
SEA WATER
MISSILE TUBE PRESSURIZATION
UNDERHATCH VALVE OPEN
LAUNCH TUBE PRESSURIZED
LAUNCHER PRESSURIZED PRESSURE SWITCH
TUBE OVER-PRESSURIZED
LAUNCHER OVER-PRESSURIZED PRESSURE SWITCH
MISSILE TUBE
UNDER HATCH VALVE
BREATHE PRESSURE NORMAL
TUBE/SEA DIFFERENTIAL PRESSURE SWITCH
LCP
SEA WATER
NITROGEN
NITROGEN ISOLATION VALVE
NITROGEN 4500 PSIG
REDUCER VALVES 4500/145 PSIG
BREATHER VALVE
AIR
AIR ISOLATION VALVE
AIR 4500 PSIG
VENT TO MC
EJECT CHAMBER ISOLATION VALVE
EJECT CHAMBER ISOLATION VALVE SHUT

33.473

Figure 7-23.—Missile tube pressurization.

MISSILE FOR STRATEGIC LAUNCH, a series of events takes place while the launch orders are being authenticated and prior to the command, SET CONDITION 1SQ FOR STRATEGIC LAUNCH being issued. The launcher supervisor opens the forward and aft hydraulic supply valves for the missile tube hydraulics. The LCP operators set the pressurization supply switch to NITROGEN, verify that the launch mode switch is set to SUBMERGED, and that the breather valve switches are set to SHUT. The LCP operators set the denote switches to LOCAL and the muzzle hatch switches to REMOTE for all tubes. The breather valve switches for the first four tubes are set to AUTO after the sea sensing lines have been opened, initiating missile tube pressurization. When missile tube pressure approximately corresponds to sea pressure at the ordered depth, the denote switches are set to REMOTE. The procedure is repeated for the remaining tubes in accordance with the firing order, in groups of four, until all tubes are pressurized.

When the CO issues the command SET CONDITION 1SQ FOR STRATEGIC LAUNCH, the arming crew manually unlocks the EBW firing units, and IMP and LCPs receive an LCC mode switch normal from fire control showing that the interface between the two systems is ready for the launch (see fig. 7-24).

When all the above conditions have been met, the LCP routes an MC condition 1 signal to IMP, resulting in an MC-in-condition-1SQ signal to fire control. This indicates that the launching system is ready to proceed with the launch sequence. The MC condition 1 signal is a result of the following conditions:

1. Missile in place
2. No IMP holds
3. No LCP holds
4. Access doors locked shut
5. Breather valve in AUTOMATIC
6. DENOTE switch in LOCAL or REMOTE
7. MUZZLE HATCH switch in REMOTE or OPEN
8. Ejector group water level normal
9. Closure detonator power on
10. Firing unit SAFE/READY switch in READY

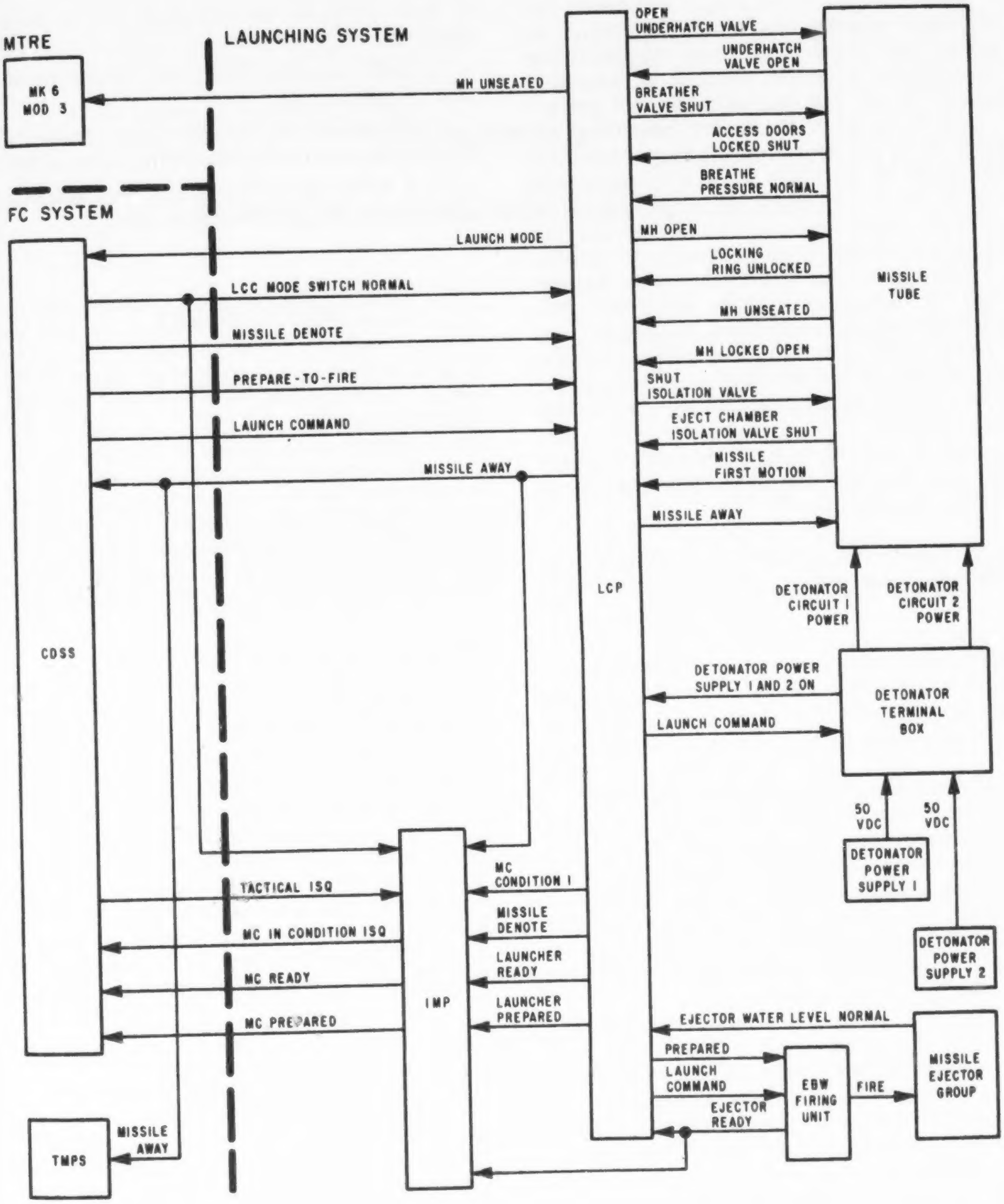
The final portion of the launch sequence is initiated when the CO grants permission to fire after the weapon system is at condition 1SQ. The denote sequence is initiated by the fire control system when the control and display subsystem (CDSS) routes a missile denote signal to the LCP. The LCP routes the missile denote signal to IMP and removes the breather valve shut command from the missile tube. When the shut command is removed, the breather valve again enters the automatic breathe mode. The missile tube is further pressurized to slightly above sea pressure at launch depth. When this pressure is attained, the missile tube routes a breathe-pressure-normal signal to the LCP, indicating the missile tube is pressurized. With breathe pressure normal and the EBW firing unit unlocked, the LCP generates and routes a launcher ready signal to IMP, which routes an MC ready signal to CDSS, indicating that the launching system has completed the denote sequence.

The muzzle hatch opening sequence is initiated by the receipt of the prepare-to-fire signal from fire control. The LCP generates and routes an MH open command to the missile tube. This initiates the following chain of events, which are locally monitored by upper-level technicians:

1. Locking ring unlocks.
2. Under-the-hatch-valve commanded shut.
3. Hatch opens.
4. Hatch unseated sent to MTRE to allow the transfer to internal power.
5. Hatch locked open by locking pins and locked open indication sent to LCP.

After the muzzle hatch is locked open, the LCP operator sets the eject system switch on the LCP to prepared, routing a prepared signal to the EBW firing unit and a launcher prepared signal to IMP. The prepared signal causes capacitors within the EBW firing unit to charge. Upon receipt of the launcher prepared signal, IMP generates and routes an MC prepared signal to CDSS (refer to fig. 7-24).

When CDSS receives the MC prepared signal and all the weapon system functions are complete, a launch command is routed to the LCP. Upon receipt of the launch command, the LCP routes the breather valve shut command and a shut isolation valve command to the missile tube and routes the launch command to the detonator terminal box and the EBW firing unit. The breather-valve-shut command shuts the breather valve to prevent it from flooding after ejection of the missile. The shut-isolation-valve command energizes a solenoid control valve that allows ship's hydraulics to shut the valve to prevent steam blow-by during missile launch.


MTRE
MK 6 MOD 3
LAUNCHING SYSTEM
FC SYSTEM
CDSS
TMPS
IMP
LCP
MISSILE TUBE
DETONATOR TERMINAL BOX
DETONATOR POWER SUPPLY 1
DETONATOR POWER SUPPLY 2
EBW FIRING UNIT
MISSILE EJECTOR GROUP
MH UNSEATED
LAUNCH MODE
LCC MODE SWITCH NORMAL
MISSILE DENOTE
PREPARE-TO-FIRE
LAUNCH COMMAND
MISSILE AWAY
OPEN UNDERHATCH VALVE
UNDERHATCH VALVE OPEN
BREATHER VALVE SHUT
ACCESS DOORS LOCKED SHUT
BREATHE PRESSURE NORMAL
MH OPEN
LOCKING RING UNLOCKED
MH UNSEATED
MH LOCKED OPEN
SHUT ISOLATION VALVE
EJECT CHAMBER ISOLATION VALVE SHUT
MISSILE FIRST MOTION
MISSILE AWAY
DETONATOR CIRCUIT 1 POWER
DETONATOR CIRCUIT 2 POWER
DETONATOR POWER SUPPLY 1 AND 2 ON
LAUNCH COMMAND
50 VDC
50 VDC
TACTICAL ISQ
MC IN CONDITION ISQ
MC READY
MC PREPARED
MC CONDITION 1
MISSILE DENOTE
LAUNCHER READY
LAUNCHER PREPARED
EJECTOR WATER LEVEL NORMAL
PREPARED
LAUNCH COMMAND
EJECTOR READY
FIRE
MISSILE AWAY

33.474

Figure 7-24.—Launching system control and monitoring.

Upon receipt of the launch command, the detonator terminal box routes the 50-volt dc power from the detonator power supplies to the missile tube departure switches as detonator circuit 1 power and detonator circuit 2 power.

Upon receipt of the launch command, the EBW firing unit capacitors discharge, routing a fire signal to the EBW initiator in the missile ejector group. At ignition of the gas generator, a mixture of gas, steam, and water enters the eject pressure chamber to smoothly eject the missile.

When the missile lifts off the missile support ring, the departure switches deactivate. The departure switches route detonator circuit 1 and 2 power to the launcher tube closure detonators. The detonators set off charges to rupture and separate the tube closure, clearing the way for missile passage. The departure switches also route a missile-first-motion signal to the LCP. The LCP then generates and routes a missile away signal to the following places:

1. Missile tube—Causes the solenoid controlled guidance coolant supply and return valves to shut—prevents contamination of this fresh water system by seawater.
2. IMP—Inhibits IMP from monitoring an expired missile tube.
3. CDSS—Enables the fire control system to prepare for the next missile in the firing order.
4. TMPS—Resets TMPS, removing guidance power from the expired missile tube.

MLS SUMMARY

This section should be used as an introduction to the launching system. For further technical information, refer to NAVORD OP 3736 for the Mk 24 launching system. Major launcher evolutions and emergency procedures are specified in the operating manual for the system. The manual (NAVORD OD43144) is divided into procedural guides (PGs), weapons procedures (WPs), and casualty procedures (CPs), which are to be strictly adhered to in carrying out any of these evolutions.

CHAPTER 8

OPTICAL ALIGNMENT GROUP

The optical alignment group (OAG) MK1 is used to measure the misalignment of a POSEIDON missile in its tube. This is accomplished by optically measuring the angular deviation of the missile and its guidance system from the required orientation. An electrical signal proportional to this angular error (Bdaim) is transmitted to Fire Control as an input to the Fire Control problem.

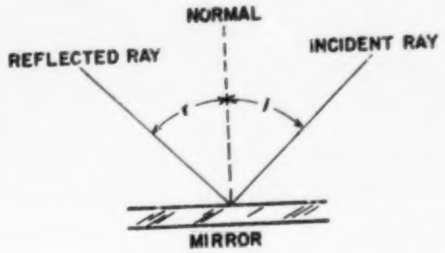
This chapter will give you a basic understanding of the optical principles and equipment used in the POSEIDON OAG.

OPTICAL PRINCIPLES

Before going into the optical system we will briefly examine some of the properties of light. To start with, light is a form of energy that is considered to travel in wave form. The waves move outward from the source as a series of concentric, rapidly expanding spheres. In the study of optical instruments, it is convenient to trace the path of light rays rather than waves. A ray is an imaginary line used to show the direction in which the light waves are moving. A ray is a radius of the sphere formed by the wavefront, and is at right angles to the wavefront. Although there is an infinite number of rays in a spherical wave, usually three rays are enough to show the path of a light beam.

Reflection

Figure 8-1 illustrates several of the terms used to describe the reflection of light. The incoming ray, from the source, is the incident ray. The normal is an imaginary straight line at right angles to the reflecting surface (in this case a mirror), passing through the point of incidence. The angle of incidence is the angle between the incident ray and the normal, and the angle of reflection is the angle between the normal and the reflected ray. The law of reflection states, first, that the angle of incidence is equal to the angle of reflection; and, second, that the incident ray, the reflected ray, and the normal all lie in the same plane.



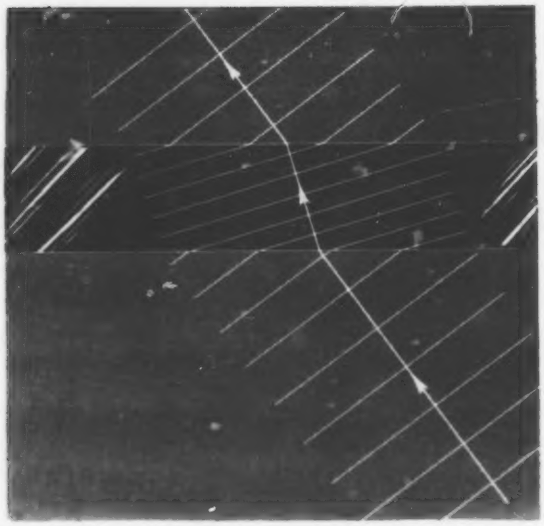
12.231

Figure 8-1.—The reflection of light.

When light strikes the surface of clear glass, a part of the light will be reflected and the rest will enter the glass. If the incident ray lies on the normal (zero angle of incidence) about 5 percent of the light will be reflected. As the angle of incidence is increased the amount of reflection increases. As the angle of incident approaches 90°, the reflection approaches 100 percent.

Refraction of Light

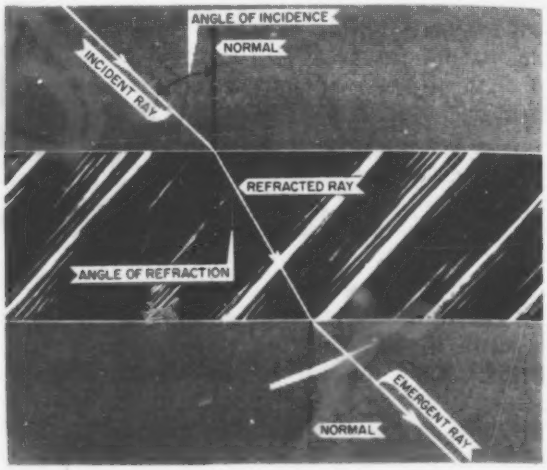
Light travels at a speed of approximately 186,000 miles per second in air. In a vacuum, its velocity is slightly higher. in a denser medium it moves more slowly. When light passes from one medium into another of different density, its velocity changes. This change in velocity makes it possible for an optical instrument to control the path of light, to form images and to magnify them.



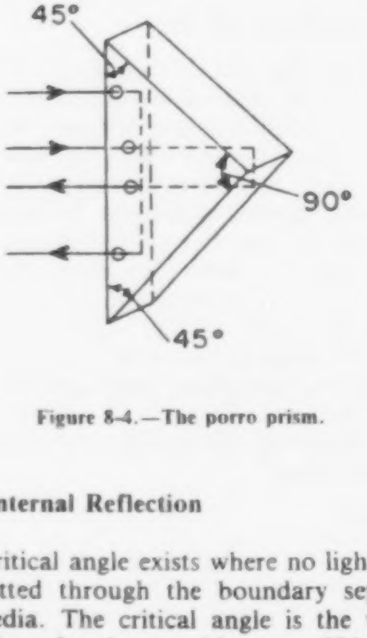
12.232
Figure 8-2.—Path of wavefronts through a sheet of glass.

In figure 8-2, a ray of light strikes a glass at an oblique angle (any angle which is not a right angle). The approaching light waves are from a distant source, and are therefore parallel. As each wave enters the glass, various points along the wave front will slow unsuccessively and as a result the entire wave front will change its angle. Since the direction of movement, shown by the ray, is at right angles to the wave fronts, the light bends as it enters the glass. The opposite effect occurs when the waves leave the glass. Now the various points along the wave successively increase their speed. As a result, the emergent waves are parallel to those that entered the glass, and the emergent ray is parallel to the incident ray, although it has been displaced to one side.

Figure 8-3 illustrates some of the terms used to describe the refractions or bending of light. The law of refraction states that light bends toward the normal when it passes into a denser medium; it bends away form the normal when it passes into a less dense medium. The exact angle of refraction depends on the angle of incidence, and on the optical density of the two media. (The index of refraction of a vacuum is one.)



12.233
Figure 8-3.—Terms used to describe the refraction of light.

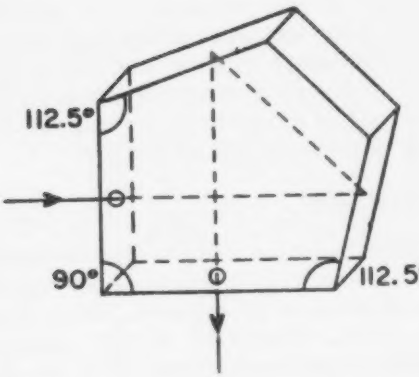


177.82
Figure 8-4.—The porro prism.

Total Internal Reflection

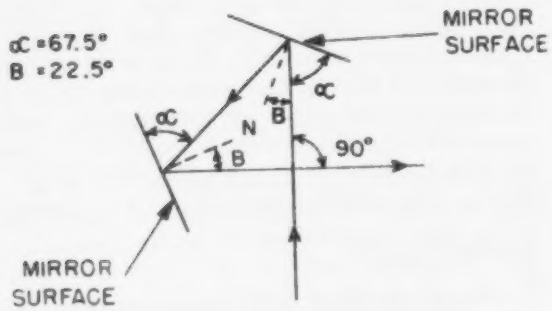
A critical angle exists where no light can be transmitted through the boundary separating two media. The critical angle is the value at which the refractive angel becomes 90°; beyond this point all light is reflected internally. Total reflection causes the boundary to act as a mirror.

If a prism is cut as shown in figure 8-4, a light ray is reflected twice inside the prism. The



137.119(117)

Figure 8-5.—The pentaprism.



177.83

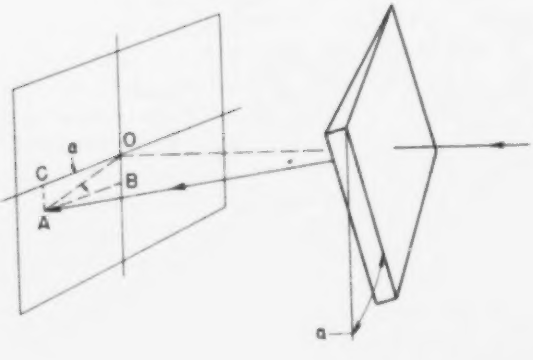
Figure 8-6.—The pentamirror.

path of the emergent ray is parallel to, but in the opposite direction from, the incident ray. The light ray is rotated through an angle of 180°. The porro prism mounted on the outer gimbal of the missile stable platform is cut in this manner. A five-sided prism is called a pentaprism (fig. 8-5). It will deviate the incident ray exactly 90°. A pentamirror unit (fig. 8-6) will also deviate the incident ray through 90°. The unit is a combination of two mirrors mounted 45° to each other. The deviation is in accord with the law of reflection. A ray reflected successively by two mirrors will be deviated from its original direction by an angle equal to twice the angle between the two mirrors.

Optical Wedges

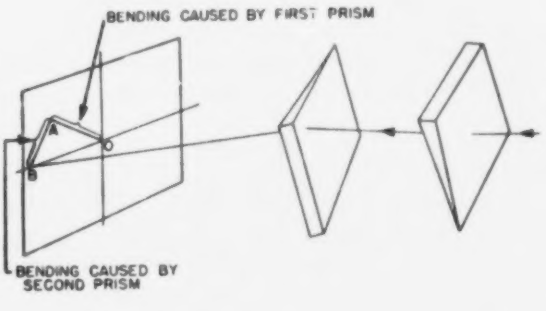
The misalignment angle is measured by deviating a light beam from its original path so that it will strike the porro prism perpendicularly. Therefore, the angle of refraction necessary to measure Bdoem will vary between missiles. A prism cut in the shape of a wedge can be rotated to provide a variable refraction angle. The direction of deviation is toward the thick side of the wedge (fig. 8-7). A ray passing through the wedge will be shifted in azimuth by a rotation of the wedge. The amount the wedge is rotated in order to shift the ray so that it will strike the porro prism at a 90° angle is proportional to Bdoem.

One difficulty remains. When the wedge is rotated, the ray will also be shifted in the vertical direction. To eliminate the vertical displacement a second wedge is placed in the light path (fig. 8-8). The second wedge is a duplicate of the



55.295

Figure 8-7.—Effect of rotating an optical wedge.



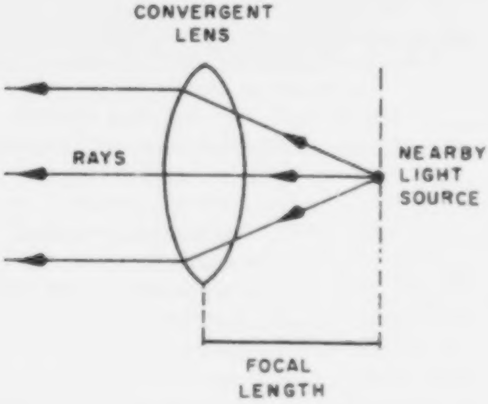
55.296

Figure 8-8.—Effect of rotating two optical wedges.

first wedge and is rotated an equal amount but in the opposite direction. The total deviation of the ray is the vectorial sum of the deviations caused by both wedges. In this arrangement the vertical deviations will cancel and the azimuth deviations will add.

Collimation

The light that enters a lens is only a small part of a sphere. If the light wave comes from a nearby source, the rays will be diverging and the wavefront will be strongly curved (fig. 8-9). Each ray that enters a convergent lens will have a different angle of incidence and will bend to a different degree. The ray that passes through the center of the lens is normal to both surfaces and therefore, is not refracted. The greater the distance from the center of the lens, the greater the incident angle of a ray and the greater the deviation. If the lens is perfect, all emergent rays will be parallel to the ray at the center of the lens and the wavefront will be straight.



177.84

Figure 8-9.—Collimating light rays.

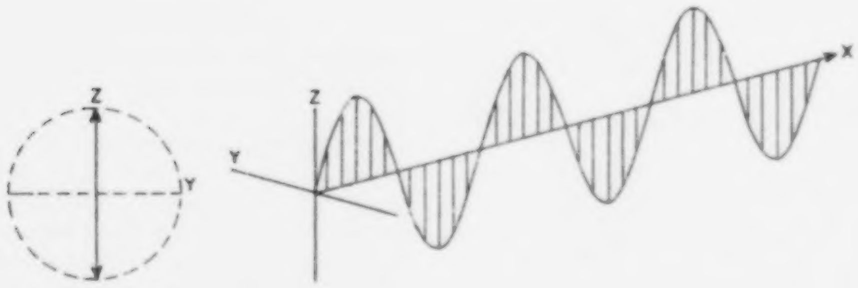
Polarized Light

The propagation of light may be thought of as the movement of a sine wave at right angles to the direction of propagation. This is shown in figure 8-10, where the X axis denotes the direction of propagation and the Z axis denotes the magnitude of the wave. The magnitude of the wave is called the E vector. Natural or unpolarized light consists of E vectors at many angles with the Z axis (figure 8-11).

Polarized light has an E vector in one plane (figure 8-10). One method of obtaining polarized light is by passing natural light through a material known as polaroid. By properly orienting the material, the plane of polarization can be set in any direction. The resultant light is plane-polarized light and only the E vector in the plane of polarization will pass through the material. The E vectors in the other planes are inhibited.

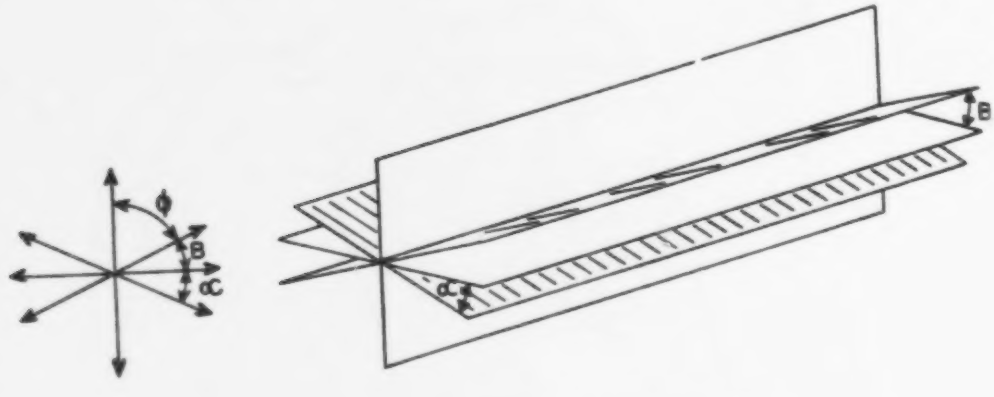
Autocollimation

Autocollimation is the process of measuring the angular displacement between a light beam striking and leaving a remote reflecting surface. The alignment group uses a photoelectric autocollimator (PEAC) that measures the angular



177.85

Figure 8-10.—Axes used to describe light propogation.



177.86

Figure 8-11.—Graphical representation of natural light.

displacement of the missile guidance system porro prism, (and other optical reflectors), and provides an electrical error output signal.

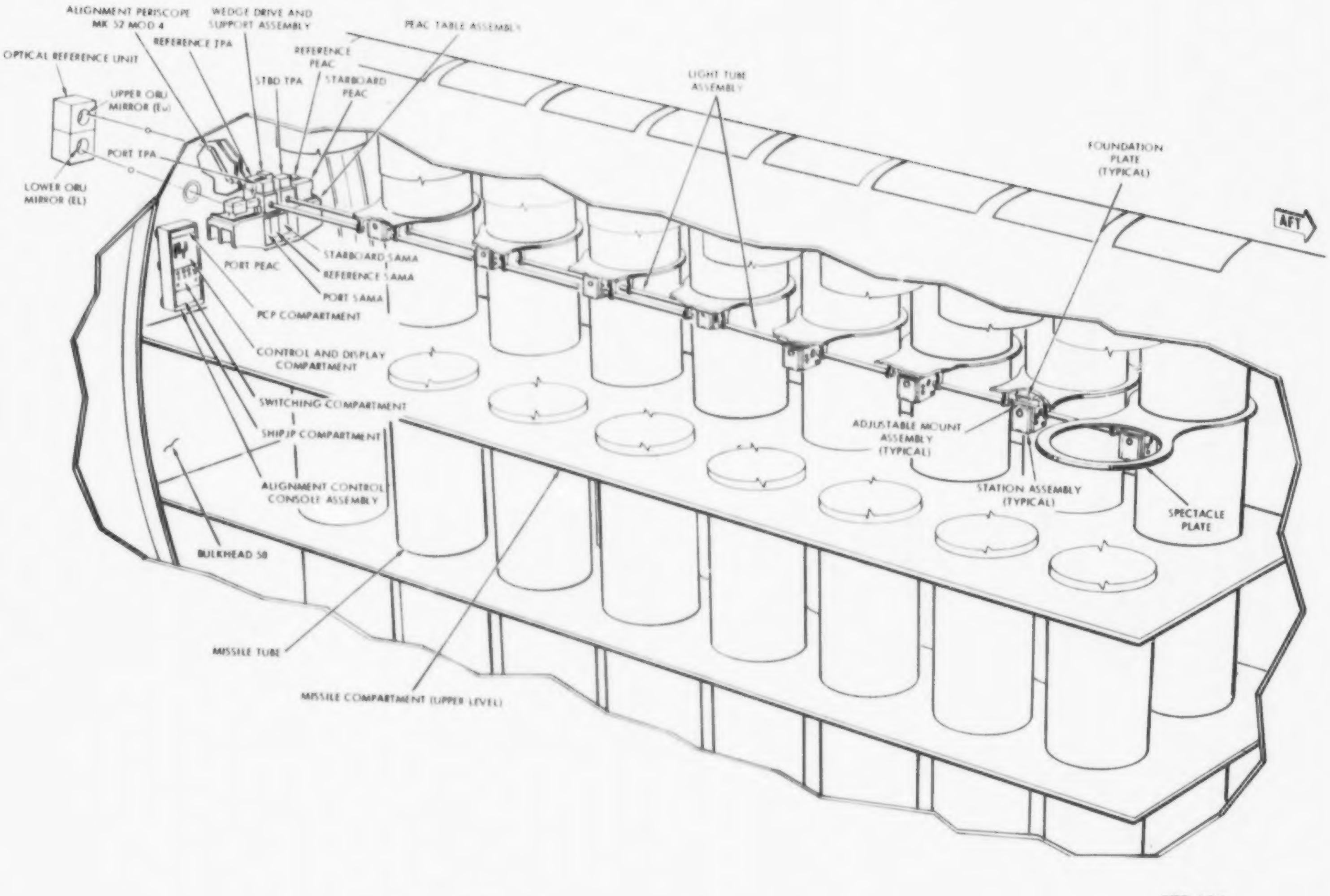
OPTICAL ALIGNMENT GROUP

The OAG provides an optical measure of any missile bearing misalignment angle (MBMA) in the deck planes of the missiles in the launch tubes prior to launch. The OAG equipment (fig. 8-12) is located primarily in the upper level of the missile compartment (MC). The OAG equipment provides the optical interface between the ship reference bearing axis established by the optical reference unit (ORU) and the missile reference bearing axes. The OAG measure angular physical changes, which may occur to the missile guidance reference axis with respect to the reference axis of the fire control-line-of-sight (fc-los); that is, any misalignment in the deck plane of the fc-los from the parallel established with the principal plane of the missile porro prism is monitored and measured by the photoelectric autocollimators (PEACs). The computed analog signals, which are proportional to the misalignment angles optically measured, are provided by the OAG. The analog signals of each missile are transmitted to the alignment subsystem (ALNSS) during coarse or fine alignment phases. During the coarse alignment phase, the OAG provides the static analog signals e(Bdaim) for all 16 missiles simultaneously as a result of any prior measurement of the MBMA, such as from missile on-loading alignment procedures. During the fine alignment phase, the OAG provides the dynamic MBMA signals Bdaim and q(Bdaim). The combination of these signals, Bdaim and q(Bdaim), in part, provide for the target bearing correction in the overall solution of the alignment problem. Figure 8-13 shows schematically the arrangement used by the OAG to perform the measurement function.

MEASUREMENT FUNCTIONS

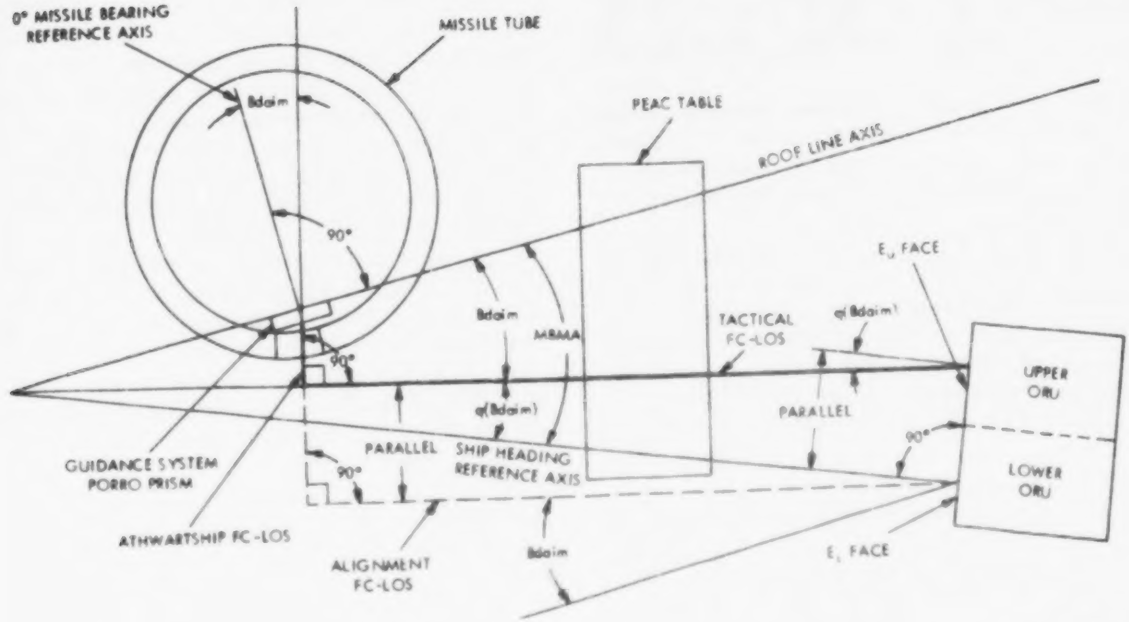
The optical line of sight (los) measurement technique used by the OAG is the method least affected by ship motion, and can operate accurately to measure angular changes in los. The los angular measurement of each missile provided by the OAG is maintained accurately over long distances within the SSBN to an established reference axis. The established reference axis is the fc-los. All OAG optical equipment is aligned to the fc-los which, in turn, is referenced to the ORU.

The OAG uses two separate optical measuring paths. The first path shown in figure 8-14, measures the Bdaim or e(Bdaim) portion of MBMA, which includes the angular rate of change induced by ship flexure. The MBMA measured in the deck plane is monitored by a PEAC whose collimated light beam is directed aft to the porro prisms of the missile guidance capsules. The second path, shown in figure 8-15, measures the


ALIGNMENT PERISCOPE MK 52 MOD 4
WEDGE DRIVE AND SUPPORT ASSEMBLY
PEAC TABLE ASSEMBLY
REFERENCE TPA
OPTICAL REFERENCE UNIT
REFERENCE PEAC
STBD TPA
STARBOARD PEAC
UPPER ORU MIRROR (Eu)
LIGHT TUBE ASSEMBLY
PORT TPA
LOWER ORU MIRROR (EL)
FOUNDATION PLATE (TYPICAL)
AFT
STARBOARD SAMA
PORT PEAC
REFERENCE SAMA
PORT SAMA
PCP COMPARTMENT
CONTROL AND DISPLAY COMPARTMENT
SWITCHING COMPARTMENT
SHIPJP COMPARTMENT
ADJUSTABLE MOUNT ASSEMBLY (TYPICAL)
ALIGNMENT CONTROL CONSOLE ASSEMBLY
STATION ASSEMBLY (TYPICAL)
SPECTACLE PLATE
BULKHEAD 58
MISSILE TUBE
MISSILE COMPARTMENT (UPPER LEVEL)

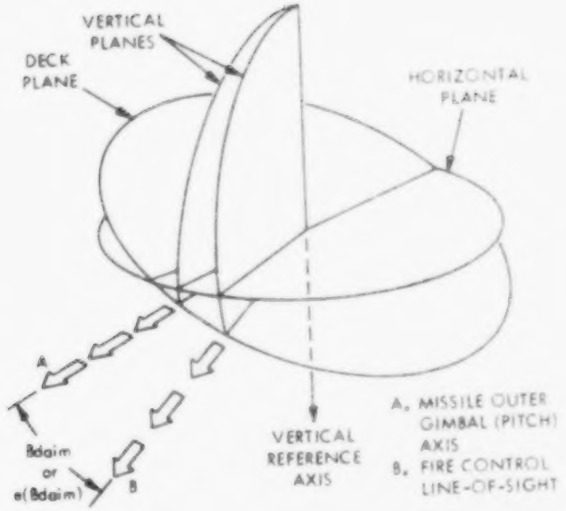
173.616

Figure 8-12.—General arrangement of optical alignment.


0° MISSILE BEARING REFERENCE AXIS
MISSILE TUBE
Bdaim
PEAC TABLE
ROOF LINE AXIS
90°
E$_u$ FACE
Bdaim
MBMA
TACTICAL FC-LOS
q(Bdaim)
UPPER ORU
90°
q(Bdaim)
PARALLEL
90°
GUIDANCE SYSTEM PORRO PRISM
PARALLEL
SHIP HEADING REFERENCE AXIS
90°
LOWER ORU
ATHWARTSHIP FC-LOS
ALIGNMENT FC-LOS
Bdaim
E$_l$ FACE

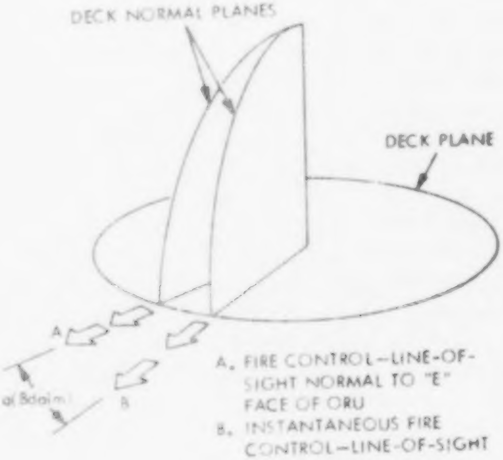
173.397

Figure 8-13.—OAG optical interface measurement.


VERTICAL PLANES
DECK PLANE
HORIZONTAL PLANE
A
Bdaim or e(Bdaim)
B
VERTICAL REFERENCE AXIS
A. MISSILE OUTER GIMBAL (PITCH) AXIS
B. FIRE CONTROL LINE-OF-SIGHT

173.618

Figure 8-14.—Bdaim or e(Bdaim).


DECK NORMAL PLANES
DECK PLANE
A
q(Bdaim)
B
A. FIRE CONTROL—LINE-OF-SIGHT NORMAL TO "E" FACE OF ORU
B. INSTANTANEOUS FIRE CONTROL—LINE-OF-SIGHT

173.619

Figure 8-15.—q(Bdaim).

dynamic portion q(Bdaim) of the MBMA as monitored by the reference PEAC. The reference PEAC light beam is transmitted forward and normal to the aft or E mirror of the ORU. The light beams of the PEACs, when aligned parallel to each other and normal to the ORU E mirror, define the alignment fc-los reference axis nominally parallel to the ship centerline Y-plane. The ORU reference axis is established by navigation from a known angular relationship to the SINS.

The OAG optically measures the MBMA (Bdaim) of the GS when installed in the launch tube, and monitors any angular deviation arising from missile or from azimuth rate of change that may be induced by ship flexure. In addition, the OAG measures (in the deck plane) the MBMA [q(Bdaim)] due to the relative motion between the ORU and the reference PEAC that may be induced by ship flexure.

The OAG measures angle Bdaim using an analog servo-optics loop. A value of e(Bdaim) can be obtained independent of the OAG dynamic operation during coarse alignment. The value of e(Bdaim) for each of the 16 missiles is the missilized static value of the Bdaim resolver. The value of e(Bdaim), obtained from the 16 Bdaim resolvers, is used in the ALNSS during the simultaneous coarse alignment of all 16 missiles. In addition, the OAG for fine alignment has a single, separate loop for the measurement of the angle q(Bdaim). In all cases, the OAG equipment uses a closed-loop servo nulling technique. When a PEAC light beam is transmitted to a porro prism or to the ORU, and is not reflected parallel to itself, an MBMA exists. The PEAC and wedge drive assembly (WDA) combination tracks the light beam, and by servo loop techniques drives a pair of contrarotating wedges. The wedges on the PEAC table are interposed in the path of the light beam and function to position the reflected light beam in azimuth until parallel to the outgoing transmitted light beam, thereby achieving a PEAC nulled servo loop for q(Bdaim). A similar set of wedges at each station assembly permits the reflected light beam from the missile porro prism to be positioned parallel to the beam transmitted by either the port or starboard PEAC. The total angle through which the two light beams have been deviated by the wedges is the MBMA. The MBMA is equal to Bdaim plus q(Bdaim).

The OAG converts the angular optically measured values Bdaim (fig. 8-14) and q(Bdaim) (fig. 8-15) into the appropriate computed electrical signals. Bdaim and q(Bdaim) values obtained by the servo-optics loop are converted by resolver, connected to the contrarotating wedge drive shaft, into dynamic analog error signals. The error signals electrically represent the optically measured MBMA.

During fine alignment channelized operation, the OAG transmits computed analog error signals Bdaim and q(Bdaim) to the ALNSS via system switching for summation with other error signals. Only one missile at a time may be prepared by the OAG. The signals combined are a part of the ALNSS target bearing correction. Signal q(Bdaim) is used during the fine alignment phase only as part of the fine alignment of an individual missile on the next-to-fire basis. Signal Bdaim is used during the missilized coarse alignment as e(Bdaim) and when switched during the channelized fine alignment operations, becomes Bdaim.

OAG EQUIPMENT

The OAG is comprised of specialized equipment which provide the necessary optical interfaces, controls, logic, and displays required to perform the preceding functions. The OAG consists of the following major components (shown in fig. 8-12):

1. 8 adjustable mount assemblies
2. 8 station assemblies
3. 1 PEAC table assembly
4. 1 Alignment Periscope Mk 52 Mod 4
5. 1 alignment control console assembly
6. 12 light tube assemblies

Adjustable Mount Assembly

The adjustable mount assemblies provide the interface between the ship and the station assemblies (STAs). The adjustable mount assemblies are mounted rigidly to the foundation plate located between a pair of port and starboard (athwartship) missile launch tubes. The foundation plate is part of the ship spectacle plate, (fig. 8-12). The adjustable mount assembly is used to adjust and align the station assembly during installation or optical realignment procedures.

Station Assembly

Four STAs are located port and four starboard of the ship centerline Y-plane. Each STA services a pair (one port, one starboard) of missiles. Each STA contains a station box, with two WEDAs and a manual input drive assembly. In use, the STA pentamirror assembly, as a part of the station box, may be indexed to direct an optical light beam from PEAC to the port side, to the starboard side, or to a see-thru position, in order to monitor the azimuth position of the porro prism of a GS. The see-thru position allows the light beam to pass through the open vee between the pair of mirrors forming two sides of the STA pentamirror, and on to subsequent STAs. Test position of the STA pentamirror is provided for installation and realignment purposes. In all cases, the STA pentamirror remains fixed until a command is received to reposition. A manual override is available to circumvent failure of automatic indexing. One WDA is mounted on the starboard side and the other on the port side of the station box. The WDA provides the drive mechanism to position the optical wedges and the output resolver. The PEAC light beam is reflected by an STA pentamirror assembly through the optical wedge to the porro prism on the GS. The porro prism (fig. 8-13) reflects the beam at an angle proportional to the missile misalignment bearing. The beam retraces the forward path through the optical wedges and the STA pentamirror back to the PEAC. The PEAC converts the position of the returning optical beam to an error signal proportional to the MBMA (Bdaim). The error signal drives the wedge drive servo motor, which contrarotates the wedges. The wedges will continue to rotate and deviate the transmitted and the reflected optical beam until the reflected optical beam is parallel with the input beam, and the error signal approaches zero. The angle through which the wedges rotate is proportional to the MBMA angle. A resolver mechanically coupled to the WDA also produces a dynamic analog signal proportional to the MBMA. The analog signal Bdaim is transmitted to the ALNSS via system switching for use during both coarse and fine alignment operations.

PEAC Table Assembly

The PEAC table assembly is located on the aft or MC side of bulkhead 58. The PEAC table subassembly is that portion of the PEAC table assembly bolted and dowelled rigidly to the bulkhead. Three adjustable PEACs are mounted on the PEAC table subassembly, with their light beams directed inboard. All are aligned parallel to each other. The PEAC table subassembly also houses the three servo amplifier assemblies (SAMAs) that are used as part of the WDA servo loops. Associated with each PEAC is the table pentamirror assembly (TPA). The TPA pentamirrors can be automatically or manually indexed. The possible combination of indexing positions of the three TPA pentamirrors allows a given PEAC light beam to be directed along the port or starboard fc-los to the STA, or directed to the ORU mirror located in the navigation center (NC). A single WDA mounted on the PEAC table subassembly is associated with the reference PEAC. The WDA-PEAC combination permits continuous measurements of the relative motion of the ORU bearing misalignment angle induced by ship flexure. The WDA operation is part of the servo-optics loop for the dynamic measuring of the misalignment angle of the reference PEAC-to-ORU. The operation and function performed by the WDA on the PEAC table is identical to that of the WDA installed on each station box. The resolver output from the PEAC table WDA resolver and reference PEAC monitoring the ORU, produce a dynamic analog signal proportional to the MBMA (q(Bdaim)). Signal q(Bdaim) is transmitted (fig. 8-14) to the ALNSS via system switching for use during the fine alignment operation on the next-to-fire, missile-channelized basis.

In addition, redirecting either the port or starboard PEAC light beam permits either PEAC to service all 16 missiles without a reduction in firing rate for a casualty operation.

Alignment Periscope

Alignment Periscope Mk 52 Mod 4 is an optical-mechanical assembly that translates the light beam fc-los horizontally and vertically from any PEAC to the ORU. The alignment periscope is mounted on the forward side of bulkhead 58.

Any change in the alignment of the reference PEAC to the upper ORU during a tactical condition is compensated for by the reference WDA.

The amount of compensation will be read off at the WDA resolver and then summed with the starboard or port PEAC WDA resolver reading to make up the MBMA used in the ALNSS.

Alignment Control Console

The alignment control console (ACC) is a compartmentalized enclosure attached by shock mounts to the aft side of bulkhead 58.

In general, the ACC provides switching and controls for OAG optical equipment. The switching also provides the control for each STA and its port and starboard PEACs. Further, the switching provides the distribution of the 800-hertz reference to the output resolver of each WDA and the transmission of the output signal of each resolver to the MCC. STA control is enabled by STA switch which, in turn, is commanded by the missile control logic of the missile to be measured. The PEACs associated with their respective STA are provided with switching to enable a paralleling operation for a casualty condition. For examble, the starboard PEAC normally handles missile 1 through 8; for a casualty operation, however, the starboard PEAC can handle missiles 9 through 16. The switching of the PEAC switch provides that the pentamirror may be indexed so that either PEAC can handle the missiles normally associated with the other PEAC with no reduction in acquisition rates.

Additional functions of the ACC include:

1. Transmitting to the CDSS, the signals required by the FCS operators to determine the status of the OAG.
2. Providing for remote/tactical (MCC) or local (MC) control.

The following is a summary of the functions performed by the controls and indicators available at the ACC for use in local or MCC remote control.

When selected for remote operation, the ACC is controlled by the CDSS. In remote operation, the ACC provides the necessary actuator-indicator(s) (A/Is) to initiate the MCC and NORMAL TPA pentamirror function. In addition, the ACC provides the necessary display, and controls to operate the OAG when commanded by the CDSS. The ACC controls and displays for SELECT and STATUS are located on the control display panel assembly (CDPA) panels, and are normally used in the remote operation.

Local operation of the ACC controls the operation of the OAG completely. The ACC provides all the A/Is, display, and controls necessary for the MC operator to perform all the required functions for local operation. All controls available for remote operation are available for local control.

Light Tube Assembly

The OAG provides 12 open-ended, hollow, cylinderical light tube assemblies (LTAs). The entire length of each LTA encompasses the light beams of both the port and starboard PEACs from the PEAC table aft to the farthest STA. Each LTA is supported near each open end by a light tube support assembly. The ends of each LTA are secured to the successive spectacle plates of each pair of launch tubes. The LTAs are arranged to be mounted concentrically around the light beams and the aperture of each STA. The LTAs then span the gap between each STA in line with the PEAC los.

The LTAs are used to maintain a stabilized path for the transmission of the PEAC light beams when in a nonstowed or operating position.

CAPABILITIES

Each STA is capable of measuring the missile MBMA (Bdaim) up to ± 30 minutes of angle. For accuracy requirements, the MBMA (Bdaim) of the missile shall not exceed ± 15 minutes of angle. Wedge angle rotation of ± 30 minutes is available for missile onloading. Either the port or the starboard PEAC is capable of measuring the MBMA (Bdaim) at any 1 of the 16 missiles during a casualty operation without any reduction in firing rates.

The OAG, when assigned to tactical/remote control, is capable of transmitting a status indication to the CDSS indicating the status of the equipment. When operating in remote control, the ACC transmits a green OAG normal signal to the CDSS indicating that the following conditions exists in the OAG equipment:

1. Both port and starboard TPA pentamirrors have a normal report position (an alternative is either a port or a starboard casualty report of TPA pentamirror positions).
2. Reference PEAC's report of a wedge null.

During remote operation, the absence of either of the preceding conditions results in a red OAG not normal condition. In addition, the presence of green or white OAG normal signal at the CDSS panel indicates that the 28-volt d.c. system power is available at the OAG. When operating in LOCAL control, the ACC transmits an OAG normal signal. This is a white signal, denoting local control is selected. In the absence of either the remote or local OAG normal signal, a red OAG STATION REPORTS alarm is displayed on the control console in MCC.

The OAG is capable of supporting the firing of missiles while in a selected LOCAL control. This capability is available on an emergency basis only. Emergency procedures require that verbal communication be established between the MCC and the MC operators to assign the STA for proper sequencing of the selected missiles next to fire. The selection of the missile on the ACC by the OAG operator then provides the proper OAG ready signal status to the control console.

When operating in remote control, the ACC transmits to the CDSS an OAG ready signal indicating that the following conditions exist in the OAG equipment:

1. STATION switch(s) is positioned
2. STA pentamirror is positioned
3. STA wedge servo is nulled
4. STA pentamirror interference does not exist
5. No OAG hold

The absence of any of the conditions noted results in an OAG ready alarm condition. The OAG ready alarm signal is switched to the channel in operation.

SYSTEM DESCRIPTION

The OAG is a subsystem of the FCS, and provides the ALNSS with the measurement of the misalignment of the missile reference bearing axis with respect to the ORU in the deck plane.

When the POSEIDON missile is initially placed in the launching tube, a small misalignment angle exists between the missile reference bearing axis of the GS and the fc-los. Another contributory factor to the MBMA is a slight movement of the missile after it is installed in the tube. These two conditions are static misalignments. The third condition, which is dynamic in nature, is the apparent MBMA induced by ship flexure. If all the contributing factors of the MBMA are not measured by the OAG and compensated for by the FCS prior to launching a missile, the missile will contain an uncompensated angular deviation error in azimuth or bearing. Various optical, electrical, and mechanical components of the OAG function to measure the angular deviation and to provide an analog output that represents the magnitude and polarity of the MBMA measurement when used for both the coarse and fine alignment phases. The MBMA, represented by the analog output, is transmitted to the ALNSS. A corrected azimuth gimbal torquer signal is generated by the ALNSS by combining the analog signals representing the target bearing, ownship heading, and relative missile bearing with the MBMA. The resulting signal represents the solution to the alignment problem for static or dynamic conditions as used in both the coarse and fine alignment phases. The optical components, which measure the missile MBMA relative to the fc-los include:

Two PEACS (one port, one starboard)
Two TPAs pentamirrors
Eight STAs (pentamirrors and optical wedges)
Sixteen missile porro prisms

In addition to the aforementioned optical components, there are components which measure the MBMA of the ORU relative to the fc-los; they are:

Alignment Periscope Mk 52 Mod 4
Reference PEAC
TPA pentamirror
Wedge drive and support assembly (optical wedges)
Optical reference unit

The measurement of the MBMA [q(Bdaim)] with respect to the ORU and the fc-los is accomplished in a manner similar to that described for the MBMA (Bdaim) measurement of the missile. The main difference is that the q(Bdaim) measurement is maintained by monitoring the forward directed PEAC light beam to the ORU; whereas, the MBMA (Bdaim) measurement is monitored by the aft-directed PEAC light beam to the porro prism. The MBMA [q(Bdaim)] measurement of the ORU, with respect to the reference PEAC, may be that which is induced by ship flexure. The polarity and magnitude of the MBMA (Bdaim) is produced by the resolver generating a computed analog signal and transmitting that signal to the ALNSS. The analog signal, which represents the q(Bdaim) MBMA, is combined with other signals in the ALNSS, and provides a dynamic bearing correction for use in the fine alignment phase. The OAG then provides the ALNSS with the required functional signals, which are used by the FCS in the solution of the alignment problem.

DETAILED ANALYSIS (ELECTRO-OPTICAL)

The general functional analysis of the OAG electro-optical components has been incorporated into the physical description portion of this chapter. Thus, the text continuity provides in one area, not only a physical picture, but also presents a functional description of how the OAG equipment operates. In the following paragraphs, the electro-optical functions are more complex and the operational theory is presented primarily as background information so that the operator may better understand the function of the optics used in the OAG.

Photoelectric Autocollimator Operational Theory

A photoelectric autocollimator (PEAC) is a precise optical instrument. It is used in conjunction with the WDA as a null-sensing device to measure the angular displacement of a reflecting surface. A PEAC automatically evaluates this angular displacement and provides an electrical output signal proportional to the displacement. Since the three PEACs in the OAG are identical in all cases, a description of the operation of one suffices for all.

The PEAC contains a series of optical components that enables it to do the following: generate a shaped beam of light; transmit this light to a remote reflector; receive this same reflected beam and analyze it with respect to the angular azimuth displacement between it and the transmitted beam; and provide electrical output signals related to the azimuth position of the reflector. These optical components also allow visual evaluation of the remote reflector position.

The shaped-light image is generated and transmitted in the following manner (fig. 8-16). The projected light beam is supplied by a 6.3-volt a.c. ribbon-filament, incandescent lamp. The filament emits uniform light intensity for the optical system. The optics are focused on the filament and the light passes to the condenser lens assembly, which contains two condenser lenses and an infrared absorbing filter. Passing through the first condenser lens, the light is collimated and transmitted to the infrared absorbing filter. This infrared absorbing filter absorbs the radiant heat from the lamp while transmitting a maximum amount of visible light energy. The heat is transferred to the condenser holder and to cooling air from a blower. The light then proceeds

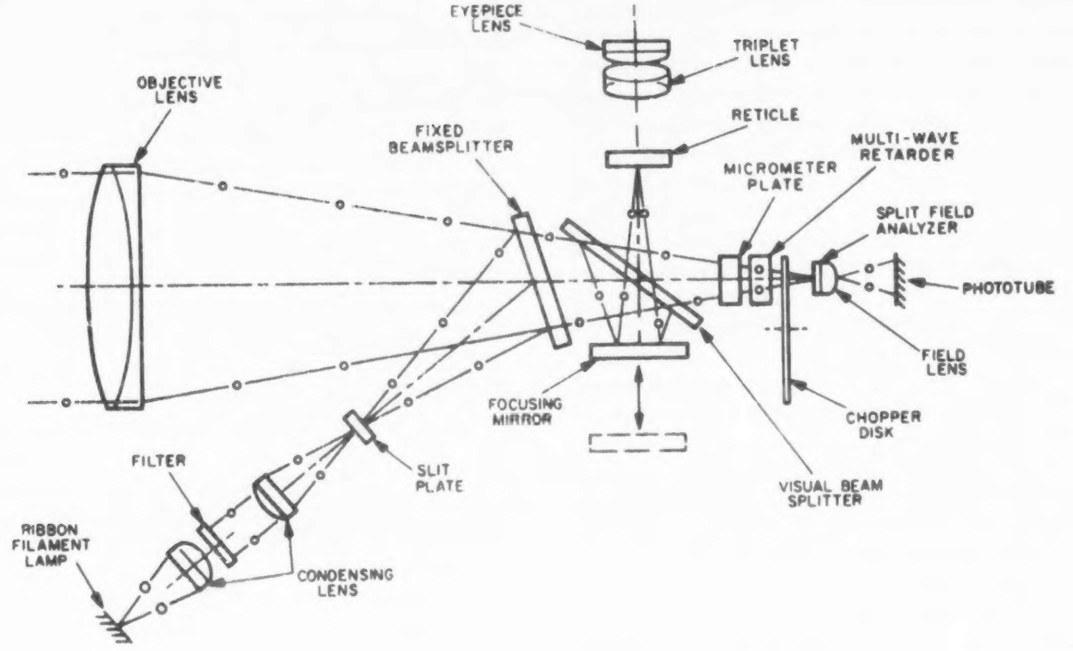

EYEPIECE LENS
TRIPLET LENS
OBJECTIVE LENS
RETICLE
FIXED BEAMSPLITTER
MULTI-WAVE RETARDER
MICROMETER PLATE
SPLIT FIELD ANALYZER
PHOTOTUBE
FIELD LENS
FOCUSING MIRROR
CHOPPER DISK
FILTER
SLIT PLATE
VISUAL BEAM SPLITTER
RIBBON FILAMENT LAMP
CONDENSING LENS

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Figure 8-16.—Photoelectric autocollimator optical schematic.

as collimated rays from the filter to the second condenser lens. This second condenser lens directs the light to the slit assembly and slit plate, bringing the beam to a focus at the back of the slit.

The slit occludes part of the light transmitted by the condenser lens to produce a sharp, clear, rectangular image of light about 0.10 inch in height and 0.01 inch in width. The slit is imaged at the focal point of the collimating lens and provides the secondary source of the PEAC light beam illumination. The size enlarges to about 3 inches in height and 0.30 inch in width as the collimated beam exits from the objective lens. Triangular pips, provided on the slit, are centered vertically on opposite sides of the image and function as a vertical reference for evaluating the slit image on the eyepiece reticle during visual operation.

Light leaving the slit assembly is incident on the partially silvered, fixed beamsplitter, which transmits and reflects light striking it. The beamsplitter is so positioned that it reflects part of the light to the objective lens. The remaining light is transmitted through the beamsplitter and absorbed by the black internal surfaces of the housing. The objective lens is a collimator, therefore the emerging light rays are parallel. This collimated light from the objective lens emerges from the PEAC and is transmitted to the remote reflector (porro prism or ORU mirror).

The remote reflector returns the light beam to the objective lens, which focuses the beam on the masked, split-field analyzer. This optical path extends from the objective lens through the fixed beamsplitter, the visual beamsplitter, the micrometer plate, the multiwave retarder, and the chopper disk. The partially silvered, visual beamsplitter diverts some of this returning light to an adjustable focusing mirror that in turn reflects the light to a reticle, which is observed through an eyepiece lens and a triplet lens assembly. Light transmitted through the visual beamsplitter passes through a micrometer plate, which permits fine azimuth adjustment of the returning light beam for centering the light beam on the split-field analyzer. For small angles of rotation of the micrometer plate, the resultant azimuth displacement of the image is proportional to the image displacement due to remote reflector azimuth deviation. The plate is adjusted by a micrometer screw and calibrated in seconds of azimuth angle of remote deviation. The micrometer control knob is graduated every second from 0 to 99, and numbered every 5 seconds from 0 to 95. The micrometer barrel has three graduations numbered 0, 100, and 200.

The multiwave retarder (depolarizer) in the PEAC makes the PEAC insensitive to the effects of any spurious polarization in the returning light beam. The removal of the polarization effect of the returning light beam ensures that all the light wave frequencies reach the rotating polarizing disk in a random fashion. The prime purpose of the multiwave retarder then is to depolarize the returning light beam by spreading the planes of polarization over all light wave frequencies. Polarization of the PEAC light beam may occur when the transmitted PEAC light beam is returned after being reflected from many surfaces used in the optical system. The depolarization of the returning light beam within the PEAC reduces the bias error to a negligible value. The returning light beam can become partially polarized or have a shift in the angle of polarization due to one or more of the following factors: (1) changes in the angular positions of the reflective surfaces; (2) changes in the number of reflective surfaces used; and/or (3) polarization of the optical components changing with changes in the internal stress. If any of the aforementioned occurs, there will be a change in the position of the polarization vector, which would cause an azimuth bias error independent of the automatic gain control (AGC). In addition to the bias error, there may exist a quadrature error that will cause a masking of the PEAC null. (The analysis of the change in the azimuth position of the polarization vector is beyond the scope of this text.) The multiwave retarder then serves to eliminate error caused by the polarization in the returning light beam by maintaining a d.c. bias, which varies only with light intensity and is compensated for by the AGC. The rotating chopper disk is a linear polarizer that is used to convert the light to a plane-polarized condition. The 400-hertz chopper motor drives the chopper disk at a synchronous speed of 200 revolutions per second (rps), orienting the plane of polarization with respect to a 400-hertz reference voltage. The phase of polarization is modulated at twice the speed of the disk or at 400 hertz. The split-field analyzer analyzes the plane-polarized, modulated light, and transmits it to the field lens. The split-field analyzer consists of two adjacent polaroid sections having mutually perpendicular axes of transmission. The returning light beam falls completely on either one section or the other, or on a combination of both, according to the magnitude of the deviation of the remote reflector. The field lens positions the returned light to the PEAC on the phototube; therefore, light transmitted by the split-field analyzer is spread by the field lens over a large area, ensuring the linear response of the phototube. The phototube converts the light energy from this input into electrical energy. The electrical output of the phototube is amplified and its phase angle is compared to the reference signal. The output of the phototube is two electrical error signals—a 400-hertz a.c. error signal and the d.c. component of this error signal. The 400-hertz error signal has an amplitude that is proportional to the remote reflector displacement, and a phase relationship (with respect to a 400-hertz reference voltage) that is indicative of the direction of reflector displacement. The d.c. voltage component of the error signal indicates that the reflected light is present in the PEAC and is being analyzed.

The amplitude of the 400-hertz error signal and the phase relationship between the reference voltage and the error signal are the result of the following events. The split-field analyzer consists of two physically adjacent portions of material that have mutually perpendicular axes of transmission. The reflected light image from the remote reflector falls completely within one of these portions or in varying combinations of both portions (fig. 8-17). The plane of polarization of the light image is rotated by the chopper disk. Therefore, the intensity of the light that reaches the phototube is sinusoidal; maximum when the plane of polarization is parallel to the transmission axis, and minimum when the plane of polarization is at right angles to the transmission axis. This occurs twice during each revolution of the disk.

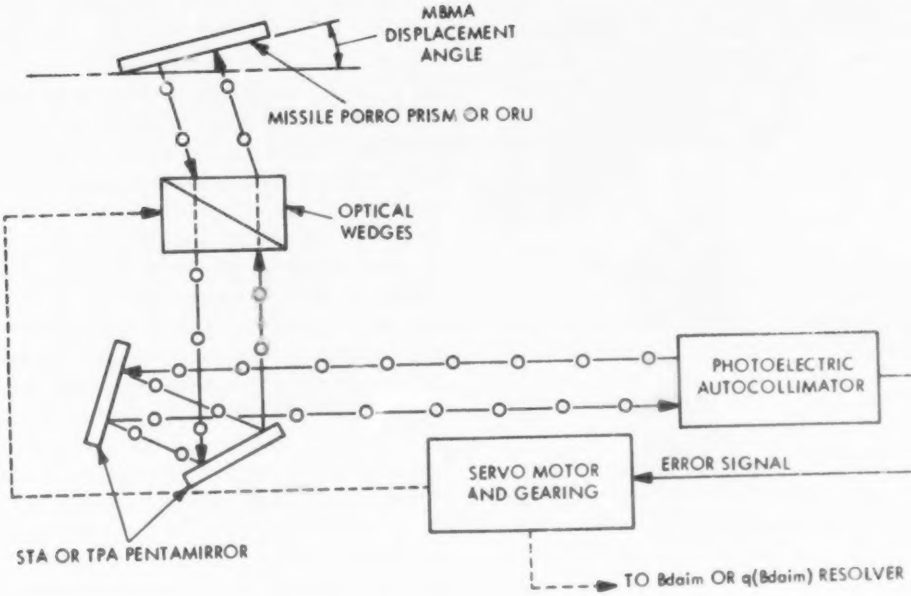

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Figure 8-17.—Optical wedge arrangement.

If the light falls on the split-field analyzer in the position shown in figure 8-18, view a, the phototube generates an electrical output proportional to the periodic intensity of the light. The phase relationship between output signal, view g, and the 400-hertz reference voltage is such that the output signal leads the 400-hertz reference voltage to 90°.

If the deviation of the remote reflector causes the beam to strike the analyzer as shown in view b, output signal, view h, has the same amplitude as the signal shown in view g; however, there is a phase difference of 180° between the two and, therefore, a phase difference of 90° (signal lagging) between the signal in view h and the reference voltage.

Similar results are obtained when the beam strikes the analyzer in the areas shown in views c and d. The resultant voltage curves, shown in views i and j, exhibit the same phase differences (with respect to the reference voltage) as the curves shown in views g and h. The amplitudes of the resultants in views i and j are dependent upon the amplitudes of the wave components transmitted simultaneously by the horizontal and vertical sections of the analyzer.

If the light is incident on the center of the analyzer as shown in view e, the horizontal and vertical components of the emergent light will have equal and opposing amplitudes; therefore, the flux intensity incident on the phototube is constant non-a.c. voltage output as shown in view k.

As previously stated, the d.c. component of the phototube output indicates that the reflected light image from the remote reflector is incident on the split-field analyzer. This d.c. output is dependent upon the intensity of the light striking the phototube. Servo error circuits provide this signal with an automatic gain control (agc) feature to maintain its amplitude at a constant level regardless of decreasing phototube sensitivity and light attentuation caused by varying light transmission.

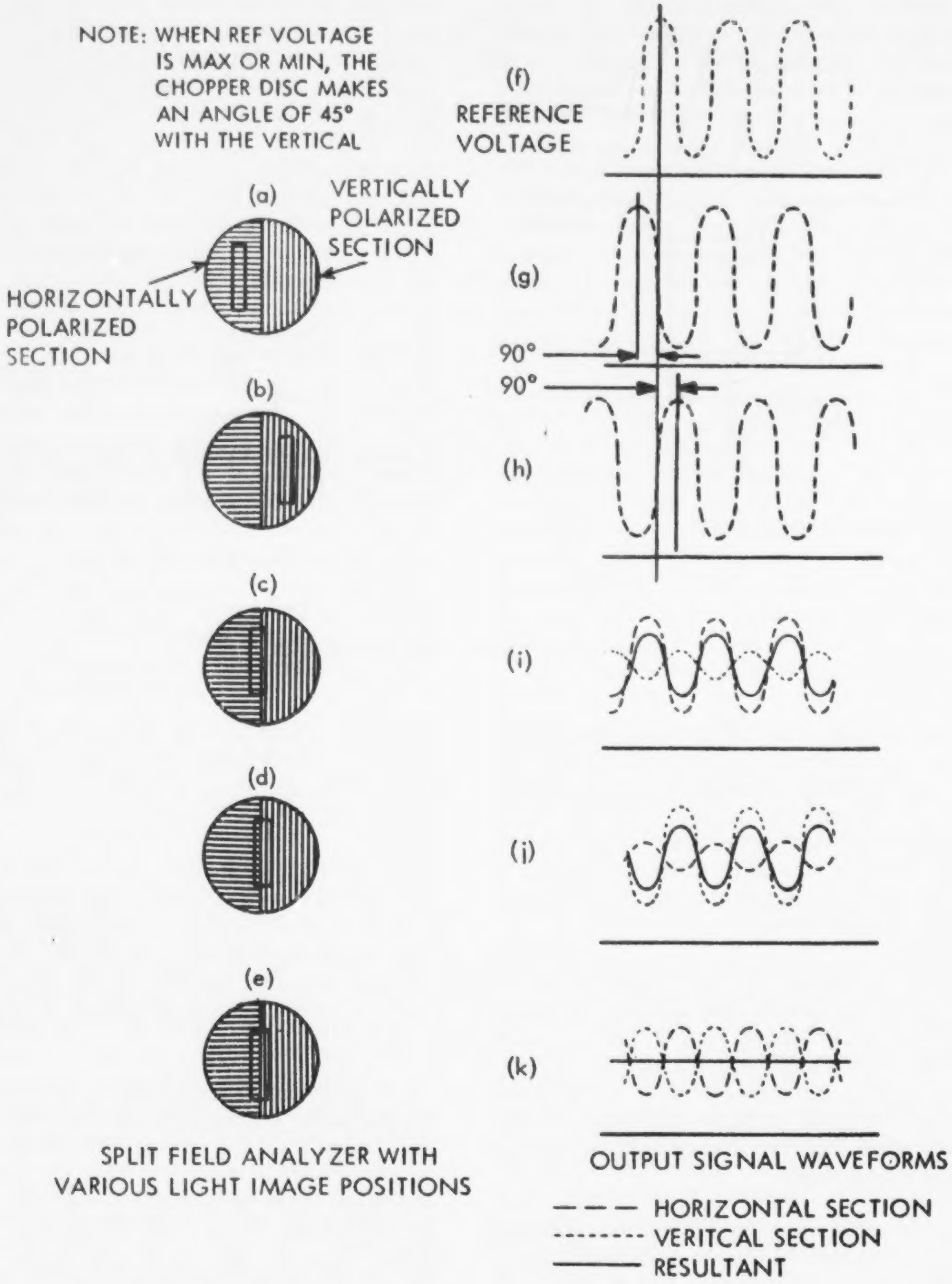
NOTE: WHEN REF VOLTAGE IS MAX OR MIN, THE CHOPPER DISC MAKES AN ANGLE OF 45° WITH THE VERTICAL
(f)
REFERENCE VOLTAGE
(a)
VERTICALLY POLARIZED SECTION
HORIZONTALLY POLARIZED SECTION
(g)
90°
90°
(b)
(h)
(c)
(i)
(d)
(j)
(e)
(k)
SPLIT FIELD ANALYZER WITH VARIOUS LIGHT IMAGE POSITIONS
OUTPUT SIGNAL WAVEFORMS
— — — HORIZONTAL SECTION
------- VERITCAL SECTION
——— RESULTANT

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Figure 8-18.—PEAC output signals.

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Wedge Drive Assembly Operational Theory

The optical wedges in the WDA are situated in the optical los of the light beam from the PEAC and the reflected light beam from the missile porro prism or the ORU cube. The wedges deviate the azimuth relationship of light beams incident upon them. When the reflected light is not parallel with the incident light, a servo motor is driven by the a.c. error signal provided by the PEAC. The servo motor rotates each wedge in opposite directions, varying the physical relationship between the surfaces and the refractive relationships between the light beams until the outgoing and incoming light beams appear parallel. The error signal from the PEAC is now zero and the wedge drive servo motor is stopped.

When the optical wedges are in this position of zero error, the transmitted beams entering and leaving the wedges are not parallel to each other. The same condition holds true for the reflected beam; however, the wedges have been turned so that their refractive qualities cause the portions of the transmitted beam and the reflected beam lying between the PEAC and the STA WDA or the PEAC table WDA to be parallel. The incident and reflected light beams from a WDA to a porro prism/ORU are also parallel and coincident. The Bdaim and q(Bdaim) resolvers are rotated through the same distance as the wedges by a mutually driven gear train; therefore, the OAG error signals Bdaim and q(Bdaim) are a function of the wedge rotation angle. Bdaim and q(Bdaim) are established by the following equation:

$$\text{Bdaim or } q(\text{Bdaim}) = 2D \sin R$$

Where R represents the wedge rotation angle in degrees, and D equals 1206 arc-seconds.

OAG SUMMARY

This section should be used as an introduction to optics and the optical alignment group. For further technical information, you should refer to NAVORD OP 3587, and OP 3804, and OD 42376.

Evolutions and emergency procedures involving the optical alignment group and the Fire Control System in general can be found in the operating manuals. These manuals are divided into PSs, WPs, and CPs, which are to be strictly adheared to in carrying out any evolution or procedure. This set of manuals is NAVORD OD 43144.

CHAPTER 9

ADMINISTRATIVE PROCEDURES

The Ballistic Missile Fire Control Technician (FTB) requires a diverse background to perform his job. An important aspect of the FTB's job is recording significant events and problems. In this chapter we attempt to give you a basic understanding of the administrative programs available to you. You must become knowledgeable of these programs to adequately perform your job as a petty officer.

To assist you in preparing for advancement and to improve your job skills, we have included information on various publications, trouble and failure reporting forms, the Navy maintenance and material management system, supply procedures, the preventive maintenance management plan, alteration programs, the calibration program, and logging requirements.

Thoroughly studying this chapter will assist you in achieving your advancement goals and in becoming an asset to your division.

PUBLICATIONS

Various sections of the Department of the Navy issue technical publications. These publications are used as sources of important information by everyone in the Navy. The publications that are of high concern to you as a Fire Control Technician are published by the Strategic Systems Program Office (SSPO), Naval Sea Systems Command (NAVSEASYSCOM or NAVSEA), Naval Supply Systems Command (NAVSUPSYSCOM), and Naval Military Personnel Command (NMPC). A description of the most important types of publications is given below.

ORDNANCE PAMPHLETS

The primary source of technical information about ordnance equipment is the Ordnance Pamphlet (OP) series. These publications are written under the direction of SSPO and published by NAVSEASYSCOM. Each OP is issued under its own identifying number. OPs are divided into two categories—equipment OPs and specific subject OPs.

The equipment OPs deal with the use of specific ordnance equipment. Each major unit of an ordnance installation is covered by an OP. The OPs you will be concerned with are the OPs on your fire control system and other components of the weapon system. The fire control system OPs contain introductory, functional, and physical descriptions of the equipment, including operation and maintenance information. The weapon system OPs give similar information on the equipment of each specific installation.

Specific subject OPs each cover a subject matter area rather than a specific unit of ordnance equipment. These OPs can serve as reference books for instruction and training. OP 3347, *United States Navy Ordnance Safety Precautions*, is a good example of a specific subject type of OP. NAVSEA OPs are listed in the *Ships Technical Publication System (STEPS) Ordnance Index*.

Ships Technical Publication System (STEPS) Ordnance Index T0751-AD-1DX-010

STEPS (formerly NAVSEA OP-0) is a listing of all types of ordnance publications stocked for issue by NAVSEA. The Index is divided into two parts. The first part is a numerical listing according to the type of publication. This part is a complete numerical listing of all NAVSEA Ordnance Pamphlets (OPs), Ordnance Data (ODs), and Ordnance Supply Office Illustrated Parts Breakdowns (OIs). In addition, it includes current Army Field Manuals (FMs) and Army Technical Manuals (TMs) used by Navy activities. For OPs, ODs, and OIs, the active publications and associated data are listed first. Following this is a list of historic publications (those that are known to be canceled or obsolete).

For active publications, the latest published change and subsequent changes under preparation are shown. Publications in the history file are listed with the latest revision and latest change associated with the publication at the time it was canceled or superseded.

Part two of STEPS is a subject listing. This part lists the ordnance publications under the appropriate system, equipment, or general subject area nomenclature. Only publications with code, mark, and mod relationships or general application for shipboard use are addressed in this section. The contents and description of STEPS may sound confusing, but it is easy to use.

USE OF STEPS INDEX.—Assume that you are working on a Mk 88 Mod 2 FCS and you want all the available publications on the system that help make your job easier.

Usually, the name and identification data of the equipment is known, rather than the number of a publication. Therefore, start with the name of the equipment (for example, Fire Control System, Mk 88 Mod 2). The first step toward finding the OPs and ODs on the system is to go to the Subject Listing (Part 2) and look under the equipment's title (Fire Control System, Mk 88 Mod 2). Here you will find the applicable OPs and ODs.

The next step is to find these numbers in the Numerical Listing (Part 1) of STEPS. The pertinent information of the OPs and ODs, such as, the title, the number of volumes, the number of revisions, and how many changes have been added, is found in this listing.

ORDNANCE DATA

Another important group of publications is the Ordnance Data (OD) series. ODs contain information on ordnance equipment, installations, routine test and inspection results, installation and alignment data, publication requirement lists, ordnance equipment lists for the ship, maintenance, and operational procedural guides. As with OPs, the ODs are listed in the STEPS Ordnance Index, OP 0. When used properly, ODs can be an important source of information to the Fire Control Technician during maintenance procedures.

SWS AND FBM WEAPON SYSTEM DOCUMENT REQUIREMENTS LIST (DRL)

The purpose of the SWS and FBM Weapon System Documentation Requirements List (DRL), OD 43853, is to specify the documentation required by SSBNs, tenders, TRIDENT refit facility (TRF), training facilities, and the FBM Navigation Test Unit for operation, maintenance, and training on the SWS and FBM weapon systems. The DRL is used as a checklist to ensure that the required documentation is onsite and current.

The DRL is divided into four chapters and one appendix as follows:

Chapter 1.	Introduction
Chapter 2.	Technical Documentation Status
Appendix B.	Navigation Test Unit Technical Documentation Status
Chapter 4.	Alphabetical Index of Fleet Technical Documentation
Chapter 5.	Numerical Index of Fleet Technical Documentation

Chapter 1 provides you with information about the distribution, requisitioning, and disposal of documentation for your facility.

Chapter 2 is divided into sections according to subsystem. It lists in numerical order the documentation required at each facility to operate and maintain the weapon system. Chapter 2 also provides the publication title, the current change status of the publication, and the source of supply if you need a change or if you are missing a volume.

Chapter 3 and Appendix A have been deleted.

Appendix B contains a list of technical documentation required by the FBM Navigation Test Unit on the USNS VANGUARD (TAG-194). Chapters 4 and 5 are useful, quick-reference alphabetical and numerical indexes of the documentation listed in chapter 2.

The DRL is revised and issued quarterly. You must make every effort to review your system publications with each new issue of the DRL to ensure that your publications are always up-to-date.

NAVY DIRECTIVE SYSTEM

The Navy Directive System is used throughout the Navy and provides a uniform plan for issuing directives that prescribe policy, organization, methods, or procedures. Conformance to the system is required of all bureaus, offices, activities, and commands of the Navy. Two types of releases are authorized under the plan—instructions and notices.

INSTRUCTIONS are directives that contain information or require action of a continuing nature. An instruction has permanent reference value and is effective until the originator supersedes or cancels it.

NOTICES are directives of a one-time nature and contain information or require action that can be completed immediately. A notice does not have permanent reference value and contains provisions for its own cancellation.

Identification

For reasons of identification and accurate filing, all directives can be recognized by the originator's authorized abbreviation; the type of release (whether an instruction or notice); a subject classification number; and in the case of instructions only, a consecutive number. (Because of their temporary nature, the consecutive number is not assigned to notices.) This information is assigned by the originator and is placed on each page of the directive.

The manner of numbering and identifying directives can be better understood by considering a typical identifier:

SSP	INST.	3100.1E
(a)	(b)	(c) (d)

(a) Here the authorized abbreviation of the originator of the directive is placed (Strategic Systems Program Office).

(b) This part refers to the type of release, in this case an instruction.

(c) This is the subject code which is determined by the subject matter of the directive, and is obtained from *Department of the Navy Standard Subject Identification Codes*, SECNAVINST 5210.11.

(d) Following the period is the consecutive number that is found only on instructions. An originator will assign consecutive numbers to those consecutive instructions with the same subject identification code. In the example above, the Subject Identification Code 3100.1 concerns "Fleet Ballistic Missile Weapon System Trouble and Failure Report System." If the originator, SSP, were to issue additional instructions dealing with the same subject, they would be assigned codes 3100.2, 3100.3, 3100.4, and so forth. The capital letter at the end of the code indicates that this instruction supersedes the previous one pertaining to this subject (for example, 3100.1E superseded 3100.1D).

Previously mentioned, SECNAVINST 5210.11 contains a numerical and alphabetical listing of numbers with their related subjects. This is of considerable value for reference use when information or instructions of a particular nature are desired. This instruction contains all the necessary information for classifying documents by subject. Certain information in the following major numerical subject groups is of interest to the Fire Control Technician.

2000 series—Operations and Readiness

4000 series—Logistics

8000 series—Ordnance Materials

Of primary interest to you as a Fire Control Technician are the directives issued by Strategic Systems Program Office (SSPO) on these and related subjects.

Twice each year, the Navy issues a Consolidated Subject Index for classified and unclassified instructions. This index contains a list of instructions in effect at that time. The list is arranged in alphabetical order according to subject group.

CHANGES TO PUBLICATIONS

Publications are continuously reviewed to keep them up-to-date. A vast amount of data on the operation, performance, testing, and maintenance of FBM ordnance equipment is received by SSPO and normally referred to the various contractors. When new methods are developed after a publication has been issued, a change to the publication is distributed by SSPO, NAVSEA, NAVSHIPS, and the like. Changes are numbered consecutively and should be made in that order. When changes become too extensive, a revised edition is published. The indexes of ordnance publications list the latest revision and the number of changes to each publication.

Here again, many changes to OPs and ODs result from TFRs sent by you and other personnel in the fleet. TFRs should be written on any document that affects system operation, reliability, or safety if that document is in some manner inaccurate. In handling publications, it is your responsibility to maintain an up-to-date set of pertinent publications, inserting changes quickly and efficiently as they arrive, and to report errors in the publications via TFRs.

Types of Changes

Message Changes (MCs) are issued to correct potentially hazardous conditions to personnel, equipment, or ammunition resulting from faulty documentation. MCs provide NAVSEA with the means of rapidly disseminating urgent change information. This type of change should be made immediately.

Advance Change Notices (ACNs) are informal, but technically complete, temporary changes to the publications. They are interim changes pending issuance of a formal change. ACN change pages do not replace pages in the manual but are inserted immediately ahead of a corrected page.

Formal Changes (CHs) are replacement pages that are used to correct technical manuals. They incorporate improvements resulting from SPALTs and an accumulation of corrections contained in the MCs and ACNs.

NAVSHIPS PUBLICATIONS

The NAVSHIPSYSCOM (replaced by NAVSEASYSCOM) was responsible for shipboard equipment, including ordnance equipment. Thus, there are still NAVSHIPS publications of interest to the FTB. Two NAVSHIPS publications that contain information used by FTBs will be pointed out here. Remember that NAVSHIPS publications will be replaced by NAVSEASYSCOM publications as revisions to the publications are sent to the fleet. Until revised, we will still call them NAVSHIPS publications for the sake of clarity.

NAVSHIPS' TECHNICAL MANUAL

NAVSHIPS' Technical Manual, NAVSHIPS 0901-000-0000 series, pertains to classes of installed machinery and equipment. This series contains what are considered to be the best engineering practices for the operation, maintenance, testing, and safety of equipment. The information is general and supplementary to the data contained in the equipment ODs and OPs.

Chapter 001 of the Naval Ships' Technical Manual Series is a general chapter that includes the new NAVSEA numbers for technical manuals you may wish to order. Its NAVSEA number is S9086-AA-STM-000/CH-001.

ELECTRONICS INSTALLATION AND MAINTENANCE BOOKS

The Electronics Installation and Maintenance Books (EIMBs), NAVSHIPS 900,000 series, are published by NAVSEASYSCOM to provide subordinate policies, and installation and maintenance information standards for people working with naval electronics equipment. The series is intended to reduce time-consuming research on electronic equipment and circuit theory. They contain a great deal of information of interest to the FTB. The series is divided into several handbooks. Each handbook can be ordered as an individual item. Of particular interest to the Fire Control Technician are the Test Equipment, General, Electronics Circuits, Test Methods and Practices, and General Maintenance handbooks.

A listing of the new proposed NAVSEA numbers for the handbooks is given below.

HANDBOOK TITLE	NAVSEA NUMBER
EIMB General Information Handbooks	
General	SE000-00-EIM-100
Installation Standards	SE000-00-EIM-110
Electronic Circuits	SE000-00-EIM-120
Test Methods and Practices	SE000-00-EIM-130
Reference Data	SE000-00-EIM-140
EMI Reduction	SE000-00-EIM-150
General Maintenance	SE000-00-EIM-160
EIMB Equipment-Oriented Handbooks	
Communications	SE000-00-EIM-010
Radar	SE000-00-EIM-020
Sonar	SE000-00-EIM-030
Test Equipment	SE000-00-EIM-040
Radiac	SE000-00-EIM-050
Countermeasures	SE000-00-EIM-060

CLASSIFIED PUBLICATIONS

Many fire control publications are classified. Most material is in the confidential category. The security measures required in the handling of classified material are covered in OPNAVINST 5510.1 (latest revision), titled *Department of the Navy Security Manual for Classified Information*. Generally, the responsibility for handling classified matter involves the receipt, accounting for, making changes to, and distribution of all such matter. Everyone who has access to classified material must be familiar with the information contained in the security manual.

Most documents on FBM equipment cannot be transmitted outside the Department of Defense without prior approval from SSPO. This stipulation is carried on title pages and is not dependent on security classification.

SPECIAL WEAPONS ORDNANCE PAMPHLETS (SWOPs)

Navy Special Weapons Ordnance Pamphlets (Navy SWOPs) are technical publications promulgated by the Joint Atomic Weapons Publications Board (JAWPB). Generally, all such publications are assigned an Atomic Energy Commission-Defense Nuclear Agency (AEC-DNA) technical publication (TP) number. In addition, the directives that have a direct bearing upon the Navy and Marine Corps will contain a Navy SWOP number. Navy SWOP 0-1, issued monthly, provides detailed information on this system and lists the effective publications included in the system.

For nuclear weapons and related equipment, the publications include: general information on definitions, reports, safety, assembly, maintenance, shipment, supply, and stocklists (series 4, 5, 20, 35, 40, 45, 100, and C1100, respectively).

Each weapon series also includes Weapons Summary (-0 series, for example, W58.35-0), Assembly, Test, and Storage Procedures (-1 series, for example, W47.35-1), Calibration (-2 series, for example, T289-2), Maintenance (-3 series, for example, W47-3), Illustrated Parts Breakdown (-4 series, for example, W58.35-4), Fuze Setting Procedures (-7 series, for example, W58.35-7), and Series Retrofits (-500 series, for example, W47-501).

The Naval Ammunition Depot, McAlester, OK, is the focal point for the control, stock, and distribution of all Navy SWOPs. The publication requirements for the various facilities are determined by the Commanding Officer, NAD McAlester, from the Naval Atomic Planning, Support, and Capabilities Report (NAPSAC). The preparation and revision of allowance lists for Navy SWOPs will be accomplished by NAD McAlester based on the NAPSAC, individual letter requests, advanced planning information, and by direction of the NAVSEASYSCOM. The

Navy SWOP allowance lists will be forwarded periodically to the activities concerned for review. Navy activities requesting changes to the allowance lists shall forward such requests to NAD McAlester via the appropriate chain of command. Additional details relating to the distribution of Navy SWOPs are found in OPNAVINST 5511.31.

These are some of the categories of publications for which you will be responsible sometime in your career as an FTB. In time, you will become quite familiar with the majority of these publications. Some of them have been detailed with reference to the fire control system in previous chapters.

TROUBLE AND FAILURE REPORTS (TFR)

The Strategic Weapon System (SWS) and the FBM Weapon System are required by SSPO to report equipment trouble and failures on trouble and failure report (TFR) forms. TFRs must be prepared on all weapon system tactical material under SSPO cognizance. This includes all weapon system equipment, navigation equipment, SSPO sonar equipment, related support equipment, and training products.

A TFR must be completed when:

1. An equipment malfunction occurs.
2. An equipment deficiency is noticed.
3. An inadequacy or error has been detected in documentation or software, EXCEPT PMMP scheduling documents.
4. During the performance of a preventive maintenance action an item is found to be defective, or a subsystem or equipment malfunction is encountered, although no failure was previously experienced.
5. A potential or actual unsafe condition is noticed that could cause injury to personnel or damage to equipment.
6. An item reported defective is tested or repaired by a fleet activity.
7. An unscheduled adjustment is made.
8. A defective spare is detected.
9. A defective SPALT kit is detected.
10. Unusual or unexpected difficulties are experienced during the accomplishment of a SPALT.
11. Specific special tools or test equipment is not available or, when available, is inadequate or unusable for the accomplishment of a repair or a maintenance action.
12. Material deterioration or damage is noticed, or inadequate or defective packaging or preservation is observed.
13. An indication of poor workmanship or other quality deficiencies are noticed.
14. An item is returned for repair or analysis.
15. An unauthorized part substitution is made or detected, or an emergency repair or alteration is performed or detected.
16. Unusual difficulties are encountered or observed in the operation (including intermittent operations), maintenance, handling, or storage of the FBM weapon system equipment. Intermittent malfunctions indicated by alarms or displays experienced in an equipment during a WSRT, OT, FOT, DASO, in transit, and so forth, may be recorded on one equipment TFR covering that period of time.
17. An elapsed time meter fails (the reading of the failed elapsed time meter and the replacement elapsed time meter shall be recorded).
18. A deficiency or problem has been detected pertaining to the calibration program, as defined in the *Calibration Program* OD and the calibration section of OD 28384.
19. Training documentation inadequate or erroneous such as training management documentation, curricula, or instructional media materials (self-study workbook), and the like.
20. A minor consumable (an item not listed in the master repairables listing), such as a switch, fuse, light bulb, fails during normal operation.

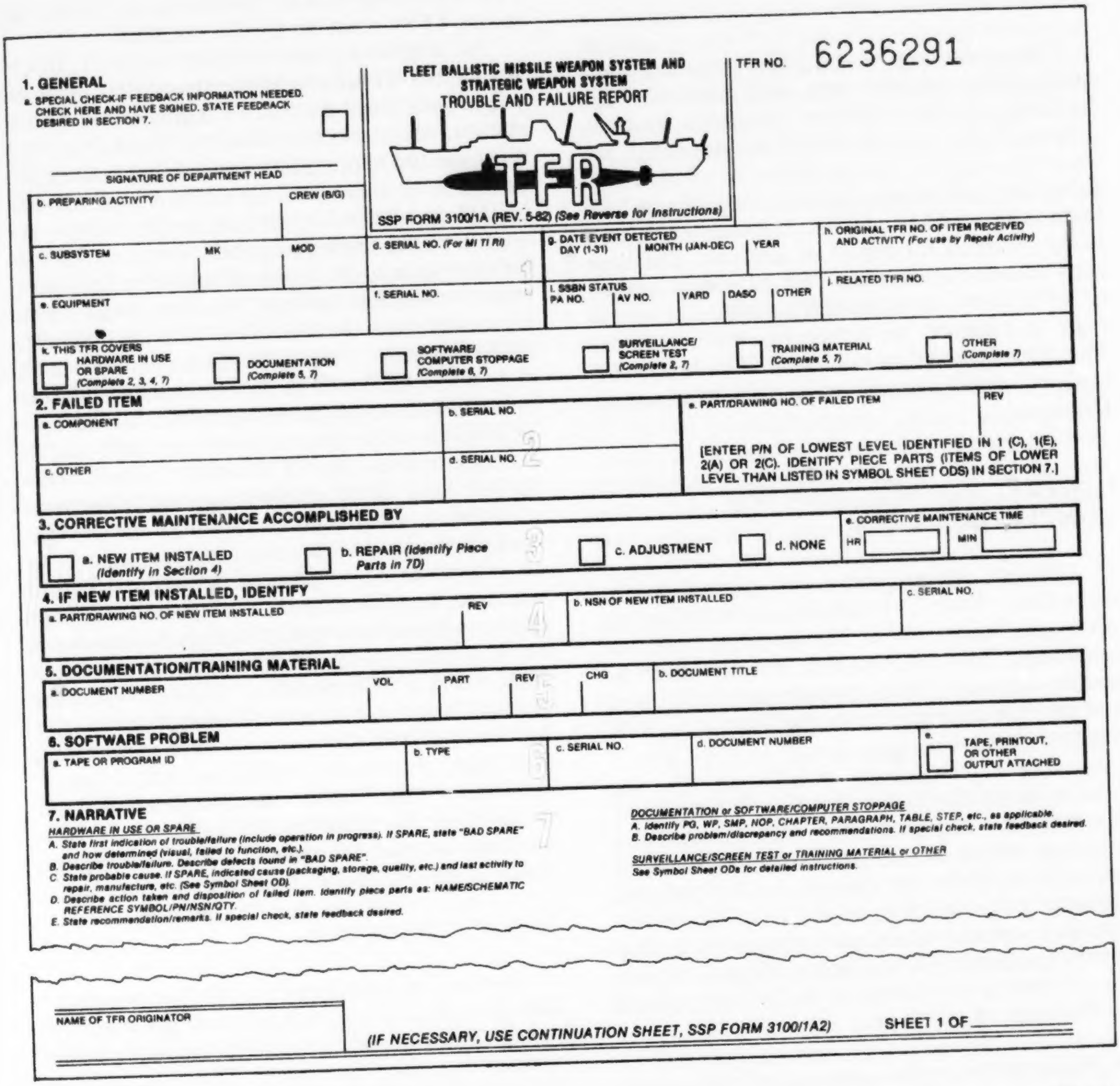
A single TFR may be used for each type of consumable to report all failures that occurred during a refit or patrol period.

When you experience or discover any of the above conditions, you must write the appropriate TFR. To ensure that the proper information is inserted in the correct location on the TFR form, TROUBLE AND FAILURE REPORT SYMBOL SHEETS FOR POSEIDON WEAPON SYSTEM (OD 53502) should be referenced.

In short, it is the bible we use for the information we need to properly manage the TFR program.

TFR FORM DISTRIBUTION

The TFR form SSP Form 3100.1A, shown in figure 9-1, is composed of four color-coded pages (one original and three carbon copies). The original (white) copy of the TFR is included in the patrol or upkeep weapon system data package upon completion of an SSBN patrol or upkeep. Special check TFRs (TFRs requiring feedback) or other significant TFRs initiated during upkeep may be mailed immediately to Fleet Analysis Center (FLTAC). The remaining TFRs are



FLEET BALLISTIC MISSILE WEAPON SYSTEM AND
STRATEGIC WEAPON SYSTEM
TROUBLE AND FAILURE REPORT

TFR

SSP FORM 3100/1A (REV. 5-82) *(See Reverse for Instructions)*

TFR NO. 6236291

1. GENERAL

a. SPECIAL CHECK-IF FEEDBACK INFORMATION NEEDED. CHECK HERE AND HAVE SIGNED. STATE FEEDBACK DESIRED IN SECTION 7. ☐

SIGNATURE OF DEPARTMENT HEAD

b. PREPARING ACTIVITY

CREW (B/G)

c. SUBSYSTEM

MK

MOD

d. SERIAL NO. *(For MI TI RI)*

g. DATE EVENT DETECTED

DAY (1-31)

MONTH (JAN-DEC)

YEAR

h. ORIGINAL TFR NO. OF ITEM RECEIVED AND ACTIVITY *(For use by Repair Activity)*

e. EQUIPMENT

f. SERIAL NO.

i. SSBN STATUS

PA NO.

AV NO.

YARD

DASO

OTHER

j. RELATED TFR NO.

k. THIS TFR COVERS

☐ HARDWARE IN USE OR SPARE *(Complete 2, 3, 4, 7)*

☐ DOCUMENTATION *(Complete 5, 7)*

☐ SOFTWARE/ COMPUTER STOPPAGE *(Complete 6, 7)*

☐ SURVEILLANCE/ SCREEN TEST *(Complete 2, 7)*

☐ TRAINING MATERIAL *(Complete 5, 7)*

☐ OTHER *(Complete 7)*

2. FAILED ITEM

a. COMPONENT

b. SERIAL NO.

c. OTHER

d. SERIAL NO.

e. PART/DRAWING NO. OF FAILED ITEM

REV

[ENTER P/N OF LOWEST LEVEL IDENTIFIED IN 1 (C), 1(E), 2(A) OR 2(C). IDENTIFY PIECE PARTS (ITEMS OF LOWER LEVEL THAN LISTED IN SYMBOL SHEET ODS) IN SECTION 7.]

3. CORRECTIVE MAINTENANCE ACCOMPLISHED BY

☐ a. NEW ITEM INSTALLED *(Identify in Section 4)*

☐ b. REPAIR *(Identify Piece Parts in 7D)*

☐ c. ADJUSTMENT

☐ d. NONE

e. CORRECTIVE MAINTENANCE TIME

HR ☐

MIN ☐

4. IF NEW ITEM INSTALLED, IDENTIFY

a. PART/DRAWING NO. OF NEW ITEM INSTALLED

REV

b. NSN OF NEW ITEM INSTALLED

c. SERIAL NO.

5. DOCUMENTATION/TRAINING MATERIAL

a. DOCUMENT NUMBER

VOL

PART

REV

CHG

b. DOCUMENT TITLE

6. SOFTWARE PROBLEM

a. TAPE OR PROGRAM ID

b. TYPE

c. SERIAL NO.

d. DOCUMENT NUMBER

e. ☐ TAPE, PRINTOUT, OR OTHER OUTPUT ATTACHED

7. NARRATIVE

HARDWARE IN USE OR SPARE

A. State first indication of trouble/failure (include operation in progress). If SPARE, state "BAD SPARE" and how determined (visual, failed to function, etc.).

B. Describe trouble/failure. Describe defects found in "BAD SPARE".

C. State probable cause. If SPARE, indicated cause (packaging, storage, quality, etc.) and last activity to repair, manufacture, etc. (See Symbol Sheet OD).

D. Describe action taken and disposition of failed item. Identify piece parts as: NAME/SCHEMATIC REFERENCE SYMBOL/PN/NSN/QTY.

E. State recommendation/remarks. If special check, state feedback desired.

DOCUMENTATION or SOFTWARE/COMPUTER STOPPAGE

A. Identify PG, WP, SMP, NOP, CHAPTER, PARAGRAPH, TABLE, STEP, etc., as applicable.

B. Describe problem/discrepancy and recommendations. If special check, state feedback desired.

SURVEILLANCE/SCREEN TEST or TRAINING MATERIAL or OTHER

See Symbol Sheet ODs for detailed instructions.

NAME OF TFR ORIGINATOR

(IF NECESSARY, USE CONTINUATION SHEET, SSP FORM 3100/1A2)

SHEET 1 OF ____

177.125

Figure 9-1.—Trouble and failure report form.

included in the patrol or upkeep data package. All other activities, including SSBNs in overhaul or conversion, must submit their TFRs at least once a week. The original copy of each TFR must be submitted to:

Officer in Charge (TFR)
Fleet Analysis Center
NWS Seal Beach
Corona, CA 91720

The green copy of the TFRs from deployed submarines, tenders, and refit facilities are forwarded to the cognizant squadron weapons officer. (This is done by SSBNs during availability and after patrol.) Other activities may destroy the green copy if desired. The blue copy of the TFR form is attached to and accompanies each item being returned for repair or analysis. The blue copy of a documentation TFR should be sent to COMSUBPAC of COMSUBLANT. The yellow copy is retained in a file for your records. This file of the yellow copies of TFRs is a useful tool in identifying recurring and intermittent failures.

GENERAL INSTRUCTIONS FOR COMPLETING A TFR

TFRs are only as good as you, the technician, make them. Each TFR should accurately reflect what you know about the problem you are reporting. This information will be used to update equipment data, upgrade your equipment, and provide information to the fleet in the TFR summary report.

You should be aware that the TFR program is continually changing. New requirements and practices will be called for as better methods of reporting troubles and failures are devised and implemented. The following is a list of the general practices, requirements, and information that currently apply to TFRs. The specific instructions for completing the sections of the TFR are printed on the back of the form.

Handwritten copies are acceptable. You should use a black ballpoint pen and verify all copies are clear, legible, and easy to read.

Section 1 (General)

When you desire specific corrective action (fleet and naval shore activities only), you must check the box in the upper left-hand corner, (refer to figure 9-1), have your department head sign the form on the line provided, and explain in section 7 the feedback information you require. This is referred to as a "special check" TFR. All safety TFRs must be special checked.

All originators must complete section 1. Block 1(i) (SSBN STATUS) applies to SSBNs only. If you are stationed on board a tender or at a shore station, you must enter dashes in block 1(i). You must use the appropriate symbol sheets for your system to identify the SUBSYSTEM and EQUIPMENT in blocks 1(c) and 1(e).

Check the appropriate box in section 1(k) to indicate your specific type of problem. DO NOT report more than one problem on a single TFR. If you checked the HARDWARE IN USE OR SPARE box, you must also complete sections 2, 3, 4, and 7 of the TFR. If you checked the box indicating that your problem is DOCUMENTATION, you must also complete sections 5 and 7. If your problem is SOFTWARE or COMPUTER STOPPAGE, complete sections 6 and 7. Software is defined as programs and routines that instruct the internal operation of a computer or other automated equipment, as well as data in machine sensible form. Computer stoppage applies when the stoppage cannot be attributed to a specific piece of hardware. You check SURVEILLANCE/SCREEN TEST to report the accomplishment of a surveillance or screen test operation of hardware assumed to be in operating condition; then also complete sections 2 and 7. Sections 5 and 7 must be completed if your problem is TRAINING MATERIAL. If your problem does not fall into any of these categories, check OTHER, and explain it in section 7.

Section 2 (Failed Item)

Section 2 includes the name of the component and its symbol or keycode. The information for blocks 2(a) and 2(c) is found in the appropriate symbol sheet for your system. The serial number (blocks 2(b) and 2(d)) may be found on the item nameplate; when unavailable, you should use the manufacturer's serial number. The part/drawing number used in block 2(e) of the TFR form is for the lowest level component you identified in blocks 1(c), 1(e), 2(a), or 2(c). This information is generally found on the failed part. Be sure to include the revision (REV) letter on the form. Block 2(f) is no longer used and has been deleted from some forms. If you use an older form (issued before January 1981), simply draw a line through this block.

Section 3 (Corrective Maintenance Accomplished By)

Section 3 is used to identify how you corrected the problem and the time required to complete the repairs. Block 3(a) is checked if you replace the lowest level component you previously identified in blocks 1(c), 1(e), 2(a), or 2(c). Block 3(b) is checked when you replace a part or component that is at a lower level than the item identified in block 2(e). Block 3(c) is checked when an adjustment is made to the equipment that restores it to a normal operating condition. Block 3(d) is checked when no corrective action was accomplished. This can be caused by a lack of replacement parts, finding a bad spare, or an intermittent fault. Block 3(e) records the time required to perform the corrective maintenance time. Corrective maintenance time is the time in hours and minutes spent working on the trouble or failure. It includes the time required to get tools and documents, troubleshoot, and run tests to ensure the system is working properly. It does not include time for meals, sleep, or time spent waiting for spare parts.

If you are assigned to an SSBN, you will report the actual time spent in the repair regardless of the number of people working on it. Tender and Repair Activities report this time in man-hours (3 men working 3 hours = 9 man-hours).

Section 4 (If New Item Installed, Identify)

Blocks 4(a), (b), and (c) are completed only if block 3(a) is checked. Block 4(a) is used for the part or drawing number and REV of the new item you placed in your system. In block 4(b) you must put the National Stock Number (NSN) of the new item. In block 4(c) you record the serial number of the new item.

Section 5 (Documentation/Training Material)

Section 5 is used only in conjunction with sections 1 and 7 to report problems with your documentation or training materials supplied by SSPO. Block 5(a) is used to identify the document number, volume number, part, revision and current change of the document. In block 5(b) you record the title as it appears on the title page. You may abbreviate where necessary to make it fit on the form.

Section 6 (Software Problem)

Section 6 is used only in conjunction with sections 1 and 7 to report problems with software of the fire control system. When software or computer stoppage anomalies occur, a dash should be entered in blocks 6(a-d). If you include any output printout or other information with the TFR form, you must also check block 6(e). The attached material must also include the number of the TFR to which it is attached.

Section 7 (Narrative)

Section 7 is very important. In this section you will be able to describe: (1) how you first found you had a problem; (2) what the problem did to the system and other indications; (3) what you feel was the probable cause of the failure; (4) what action you took; (5) what you did with the failed parts; and (6) any recommendations or remarks you feel will improve the part or method of isolating the problem in the future.

The information that you will put in the various blocks of section 7 of the TFR form will vary according to the type of TFR you are writing. (This was determined in block 1(k) of the TFR form.) Figure 9-2 shows the narrative requirements for each type of TFR report. At times you will need additional space for your narrative or wish to include a drawing. The TFR continuation form (SSP form 3100/1A2) is available for the purposes previously given. You must write the number of the associated TFR in the upper right corner of the form.

These are general instructions. At times, you will require detailed instructions to report an extensive or very different problem. In these cases, you should refer to the OD symbol sheets appropriate to your FCS for further information.

The proper use of the TFR program is a tremendous asset to you as a technician. The information and thought put into filling out a TFR can make your job and the job of future Fire Control Technicians more enjoyable. Many of the improvements found in your FCS are directly attributable to problems encountered and reported on a TFR in previous fire control systems.

7. NARRATIVE

HARDWARE IN USE OR SPARE

A. State first indication of trouble/failure (include operation in progress). If SPARE, state "BAD SPARE" and how determined (visual, failed to function, etc.).
B. Describe trouble/failure. Describe defects found in "BAD SPARE".
C. State probable cause. If SPARE, indicated cause (packaging, storage, quality, etc.) and last activity to repair, manufacture, etc. (See Symbol Sheet OD).
D. Describe action taken and disposition of failed item. Identify piece parts as: NAME/SCHEMATIC REFERENCE SYMBOL/PN/NSN/QTY.
E. State recommendation/remarks. If special check, state feedback desired.

DOCUMENTATION or SOFTWARE/
COMPUTER STOPPAGE

A. Identify PG, WP, SMP, NOP, CHAPTER, PARAGRAPH, TABLE, STEP, etc., as applicable.
B. Describe problem/discrepancy and recommendations. If special check, state feedback desired.

SURVEILLANCE/SCREEN TEST or
TRAINING MATERIAL or OTHER

See Symbol Sheet ODs for detailed instructions.

Figure 9-2.—Narrative requirements.

The mechanics of the TFR system are simple, especially when compared to other systems used in the Navy today. The benefits you derive from the program depend on the time and effort each of us expend in making the program work. You must take the time to report each problem you encounter. DON'T rely on anyone on the next watch or at a different command to do your job for you, DO it yourself.

NAVY MAINTENANCE AND MATERIAL MANAGEMENT SYSTEM

The maintenance of equipment that is not covered by the PMMP is included in the Navy Maintenance and Material Management Systems (3-M Systems). The 3-M Systems were developed to coordinate maintenance work and data throughout the Navy. To accomplish this extensive program, the 3-M Systems are divided into the planned maintenance subsystem (PMS), the maintenance data collection subsystem (MDCS), and the intermediate maintenance activity maintenance subsystem (IMMS). Details of the 3-M system are available in the *Ships' Maintenance and Material Management (3-M) Manual*, OPNAVINST 4790.4. The system is introduced in *Military Requirements for Petty Officer Third Class*, NAVEDTRA 10044.

Since the majority of your system maintenance is covered by the PMMP, the 3-M Systems will be briefly covered in this manual.

PLANNED MAINTENANCE SYSTEM

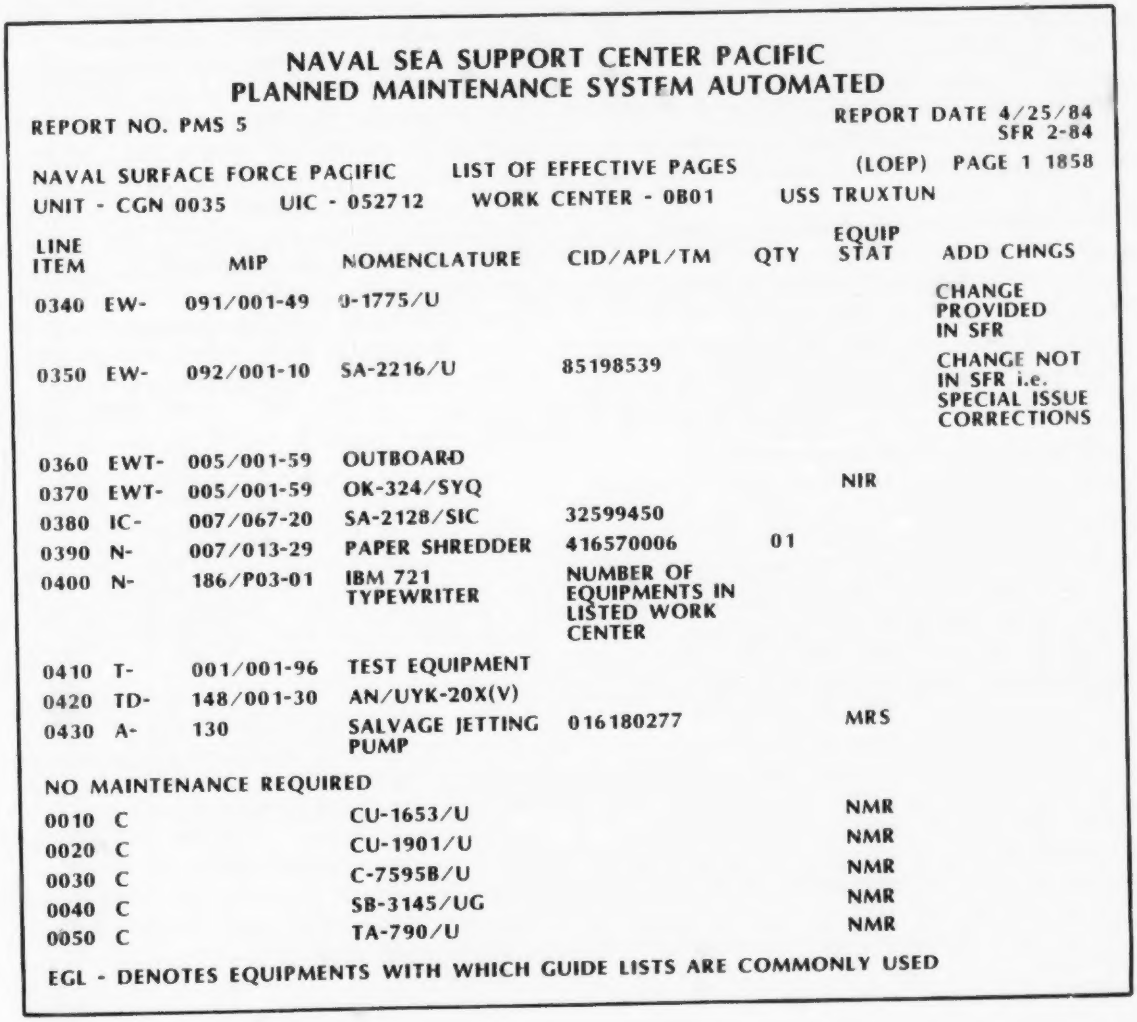
The PMS provides a simple and standard means to plan, schedule, and perform planned maintenance of equipment. Maintenance actions included in PMS are the minimum necessary to keep equipment in good operating order. Properly performed preventive maintenance identifies parts, components, or equipment that require adjustment, repair, or replacement to preclude future failures. The system is managed using a series of records, procedures, and schedules, which will be discussed individually.

Departmental Master PMS Manual

The departmental master PMS manual contains information on the equipment covered by PMS for the entire department. The list of effective pages (LOEP) in the master PMS manual is a listing of maintenance index pages (MIPs) for the department divided into work centers. This manual is used by the departmental 3-M Systems assistant to determine the maintenance requirements for each work center.

Work Center PMS Manual

The senior petty officer within a work center is assigned as the work center supervisor. He uses the work center PMS manual to schedule PMS jobs. The work center manual has a LOEP (fig. 9-3) that contains only the PMS requirements for



NAVAL SEA SUPPORT CENTER PACIFIC
PLANNED MAINTENANCE SYSTEM AUTOMATED

REPORT NO. PMS 5 REPORT DATE 4/25/84
SFR 2-84

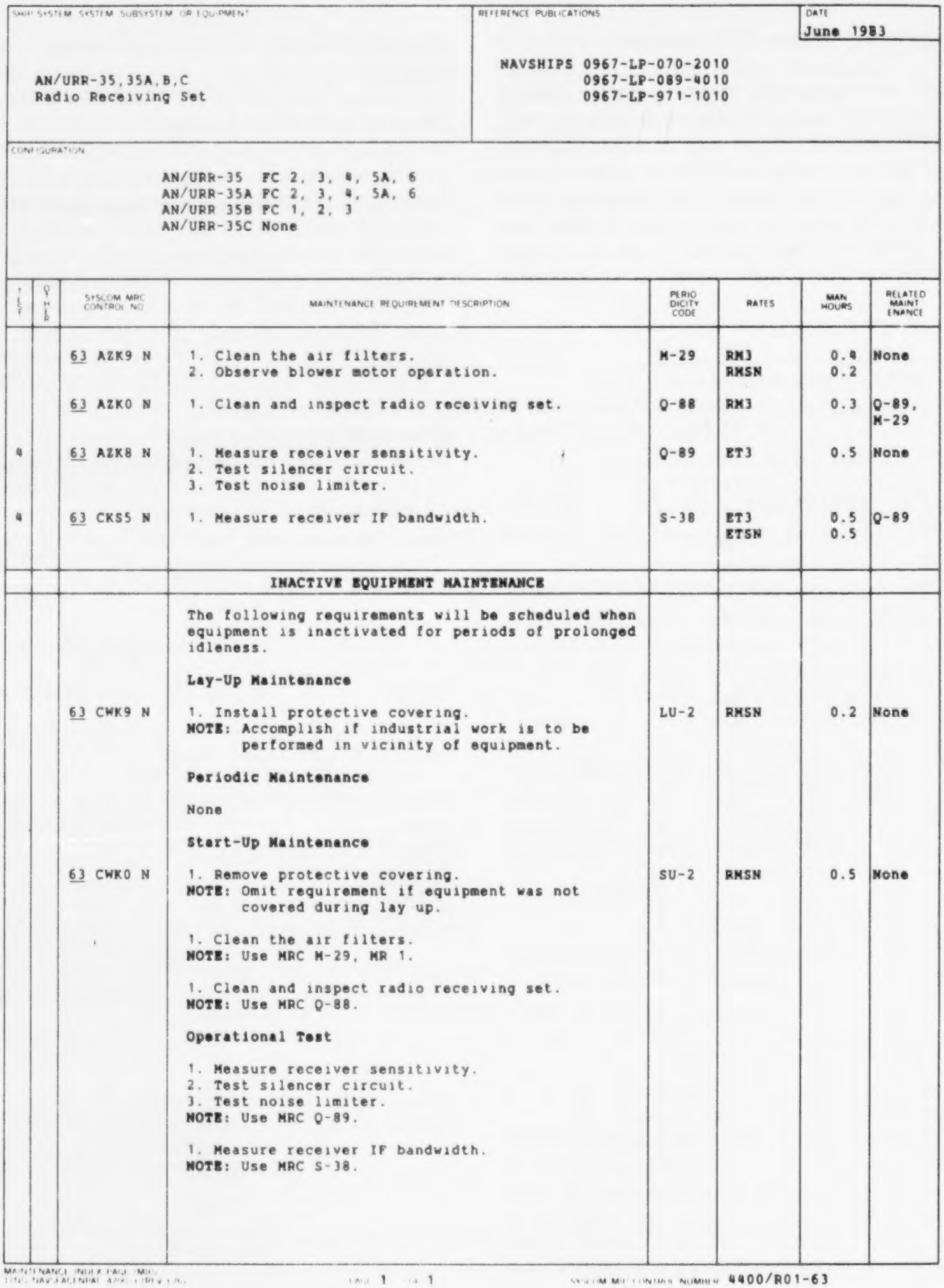
NAVAL SURFACE FORCE PACIFIC LIST OF EFFECTIVE PAGES (LOEP) PAGE 1 1858
UNIT - CGN 0035 UIC - 052712 WORK CENTER - 0B01 USS TRUXTUN

LINE ITEM	MIP	NOMENCLATURE	CID/APL/TM	QTY	EQUIP STAT	ADD CHNGS
0340	EW- 091/001-49	0-1775/U				CHANGE PROVIDED IN SFR
0350	EW- 092/001-10	SA-2216/U	85198539			CHANGE NOT IN SFR i.e. SPECIAL ISSUE CORRECTIONS
0360	EWT- 005/001-59	OUTBOARD				
0370	EWT- 005/001-59	OK-324/SYQ			NIR	
0380	IC- 007/067-20	SA-2128/SIC	32599450			
0390	N- 007/013-29	PAPER SHREDDER	416570006	01		
0400	N- 186/P03-01	IBM 721 TYPEWRITER	NUMBER OF EQUIPMENTS IN LISTED WORK CENTER			
0410	T- 001/001-96	TEST EQUIPMENT				
0420	TD- 148/001-30	AN/UYK-20X(V)				
0430	A- 130	SALVAGE JETTING PUMP	016180277		MRS	
NO MAINTENANCE REQUIRED						
0010	C	CU-1653/U			NMR	
0020	C	CU-1901/U			NMR	
0030	C	C-7595B/U			NMR	
0040	C	SB-3145/UG			NMR	
0050	C	TA-790/U			NMR	

EGL - DENOTES EQUIPMENTS WITH WHICH GUIDE LISTS ARE COMMONLY USED

177.126

Figure 9-3.—List of effective pages.



SHIP SYSTEM, SYSTEM, SUBSYSTEM, OR EQUIPMENT

AN/URR-35,35A,B,C
Radio Receiving Set

REFERENCE PUBLICATIONS

NAVSHIPS 0967-LP-070-2010
0967-LP-089-4010
0967-LP-971-1010

DATE

June 1983

CONFIGURATION

AN/URR-35 FC 2, 3, 4, 5A, 6
AN/URR-35A FC 2, 3, 4, 5A, 6
AN/URR 35B FC 1, 2, 3
AN/URR-35C None

TEST	OTHER	SYSCOM MRC CONTROL NO	MAINTENANCE REQUIREMENT DESCRIPTION	PERIODICITY CODE	RATES	MAN HOURS	RELATED MAINTENANCE
		63 AZK9 N	1. Clean the air filters. 2. Observe blower motor operation.	M-29	RM3 RMSN	0.4 0.2	None
		63 AZK0 N	1. Clean and inspect radio receiving set.	Q-88	RM3	0.3	Q-89, M-29
4		63 AZK8 N	1. Measure receiver sensitivity. 2. Test silencer circuit. 3. Test noise limiter.	Q-89	ET3	0.5	None
4		63 CKS5 N	1. Measure receiver IF bandwidth.	S-38	ET3 ETSN	0.5 0.5	Q-89
			INACTIVE EQUIPMENT MAINTENANCE				
			The following requirements will be scheduled when equipment is inactivated for periods of prolonged idleness.				
			Lay-Up Maintenance				
		63 CWK9 N	1. Install protective covering. **NOTE:** Accomplish if industrial work is to be performed in vicinity of equipment.	LU-2	RMSN	0.2	None
			Periodic Maintenance				
			None				
			Start-Up Maintenance				
		63 CWK0 N	1. Remove protective covering. **NOTE:** Omit requirement if equipment was not covered during lay up. 1. Clean the air filters. **NOTE:** Use MRC M-29, MR 1. 1. Clean and inspect radio receiving set. **NOTE:** Use MRC Q-88.	SU-2	RMSN	0.5	None
			Operational Test				
			1. Measure receiver sensitivity. 2. Test silencer circuit. 3. Test noise limiter. **NOTE:** Use MRC Q-89. 1. Measure receiver IF bandwidth. **NOTE:** Use MRC S-38.				

MAINTENANCE INDEX PAGE (MIP)
[illegible]

PAGE 1 OF 1

SYSCOM MIP CONTROL NUMBER 4400/R01-63

177.127

Figure 9-4.—Maintenance index page.

that individual work center. On the LOEP is a listing of work center equipment, their status, and applicable MIPS. The quarterly force revision (QFR) number in the upper right-hand corner of the LOEP shows the quarter and year in which the LOEP is applicable (3-84 would be the third quarter of 1984).

Maintenance Index Page (MIP)

A MIP (fig. 9-4) for each piece of equipment supported by PMS is included in the work center PMS manual. The MIP is an index listing all the maintenance requirement cards (MRCs) applicable to a system, subsystem, or piece of equipment. Each MIP shows the system or equipment, reference publications, applicable MRC numbers, and a brief description of the maintenance to be performed. A periodicity code indicates how often the maintenance is to be performed. A "T" in the test column indicates that the MRC includes one or more tests. Also shown on the MIP are the number of personnel required, their recommended skill level, man-hours to complete the MRC, and related maintenance.

The periodicity codes for the maintenance are listed below.

D—Daily
W—Weekly
M—Monthly
Q—Quarterly
S—Semi-annually
A—Annually
18M—18 Months

When more than one MRC of the same periodicity exists in the same MRC set, they are labeled consecutively (D-1, D-2, D-3, and so on). All the numbers in a sequence may not be present because of reapplication of an existing MRC to a revised MIP.

An "R" in a MIP periodicity code stands for a "situation requirement." If the situation must occur before the maintenance is scheduled, the "R" is at the beginning of the periodicity code and the code is followed by a brief explanation (R-1W: Note: when at sea, schedule lubrication weekly). If the code is a combination of regularly scheduled maintenance and a situation, the "R" follows the code (W-3R: Weekly or after each use, whichever occurs first).

A "U" as a periodicity code indicates unscheduled maintenance actions required to restore equipment to fully operational condition following failures or other problems.

Maintenance Requirement Card

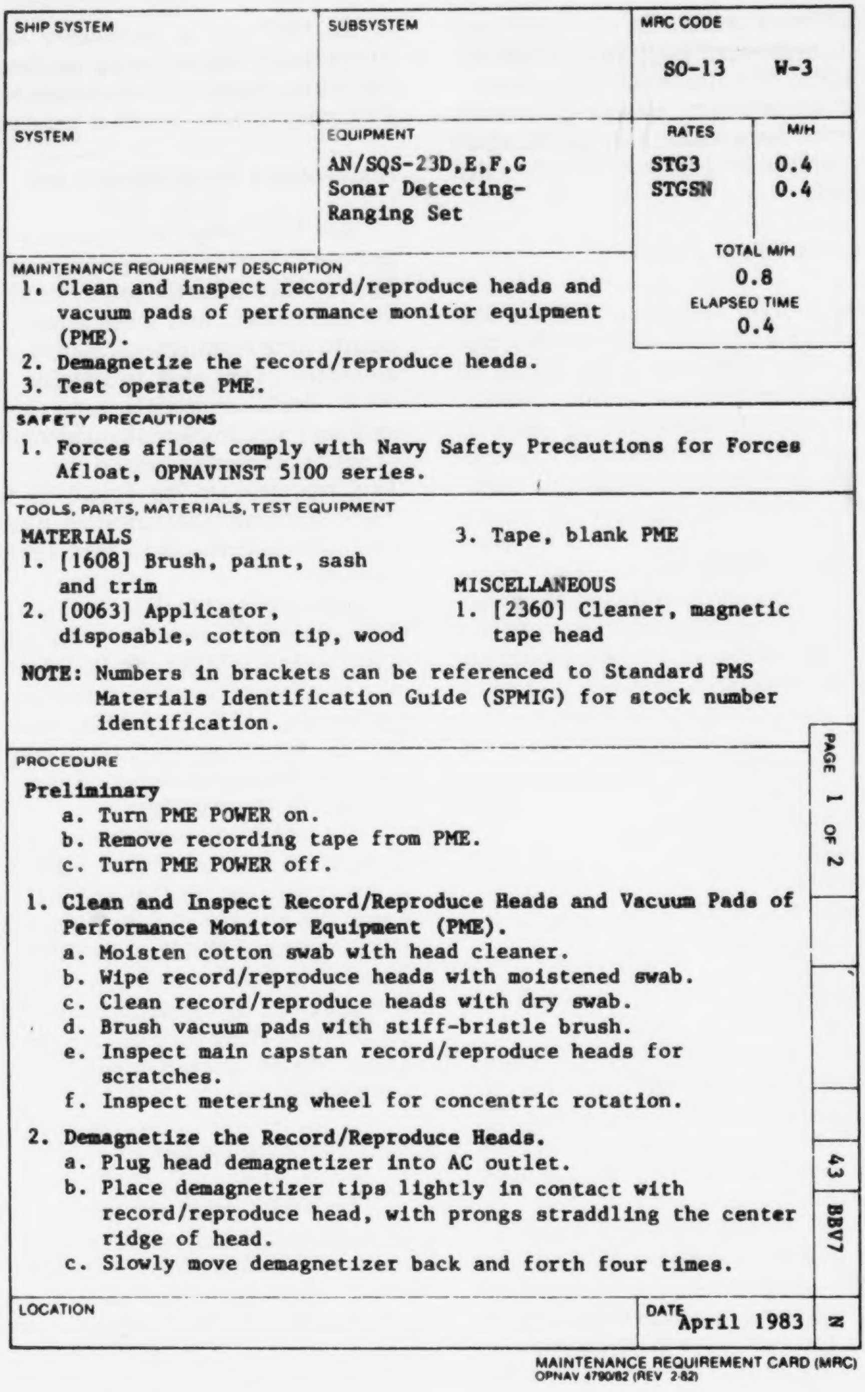
An MRC (fig. 9-5) provides detailed procedures to perform a required maintenance task. The card identifies the job by its MRC code, lists the equipment, and gives a description of the maintenance requirements. Safety precautions are also listed on the card. In addition, the MRC lists tools, parts, materials, and test equipment necessary to complete the maintenance. The list of materials also includes a number in brackets. This number can be found in the Standard PMS Materials Identification Guide (SPMIG) and cross-referenced to find the proper stock number.

The location block is used to tell you where the equipment is located or refer you to an equipment guide list (EGL). An EGL lists the locations of a number of identical items that are covered by the same MRC. Each MRC using an EGL will have the appropriate EGL(s) attached. Each EGL contains only the number of items that can be serviced in a single day.

If an MRC is confidential, an unclassified locator will be placed in the MRC file. The card is identical to the MRC except that the procedure block will give the classification and location of the confidential MRC. A master MRC deck that includes the MRCs and EGLs of each work center is maintained by the department. In addition, a complete working deck of applicable MRCs and EGLs will be located in MRC holders in each work center.

PMS Feedback Report

The PMS feedback report (fig. 9-6) is designed to provide the ship with an easy method of recommending changes to MRCs, ordering MRCs which have been lost or multilated, or notifying the systems commands of any discrepancies in coverage. The report form is made up of five sheets. The original (white copy) and the yellow copy are sent to the addressee. The pink copy is sent to the type commander. The blue copy is used on the ship by the PMS coordinator, and the green copy is kept by the originator.



SHIP SYSTEM	SUBSYSTEM	MRC CODE SO-13 W-3
SYSTEM	EQUIPMENT AN/SQS-23D,E,F,G Sonar Detecting- Ranging Set	RATES: STG3 0.4 M/H STGSN 0.4 M/H TOTAL M/H 0.8 ELAPSED TIME 0.4

MAINTENANCE REQUIREMENT DESCRIPTION

1. Clean and inspect record/reproduce heads and vacuum pads of performance monitor equipment (PME).
2. Demagnetize the record/reproduce heads.
3. Test operate PME.

SAFETY PRECAUTIONS

1. Forces afloat comply with Navy Safety Precautions for Forces Afloat, OPNAVINST 5100 series.

TOOLS, PARTS, MATERIALS, TEST EQUIPMENT

MATERIALS
1. [1608] Brush, paint, sash and trim
2. [0063] Applicator, disposable, cotton tip, wood
3. Tape, blank PME

MISCELLANEOUS
1. [2360] Cleaner, magnetic tape head

NOTE: Numbers in brackets can be referenced to Standard PMS Materials Identification Guide (SPMIG) for stock number identification.

PROCEDURE

Preliminary
- a. Turn PME POWER on.
- b. Remove recording tape from PME.
- c. Turn PME POWER off.

1. **Clean and Inspect Record/Reproduce Heads and Vacuum Pads of Performance Monitor Equipment (PME).**
   - a. Moisten cotton swab with head cleaner.
   - b. Wipe record/reproduce heads with moistened swab.
   - c. Clean record/reproduce heads with dry swab.
   - d. Brush vacuum pads with stiff-bristle brush.
   - e. Inspect main capstan record/reproduce heads for scratches.
   - f. Inspect metering wheel for concentric rotation.
2. **Demagnetize the Record/Reproduce Heads.**
   - a. Plug head demagnetizer into AC outlet.
   - b. Place demagnetizer tips lightly in contact with record/reproduce head, with prongs straddling the center ridge of head.
   - c. Slowly move demagnetizer back and forth four times.

PAGE 1 OF 2

43

BBV7

LOCATION

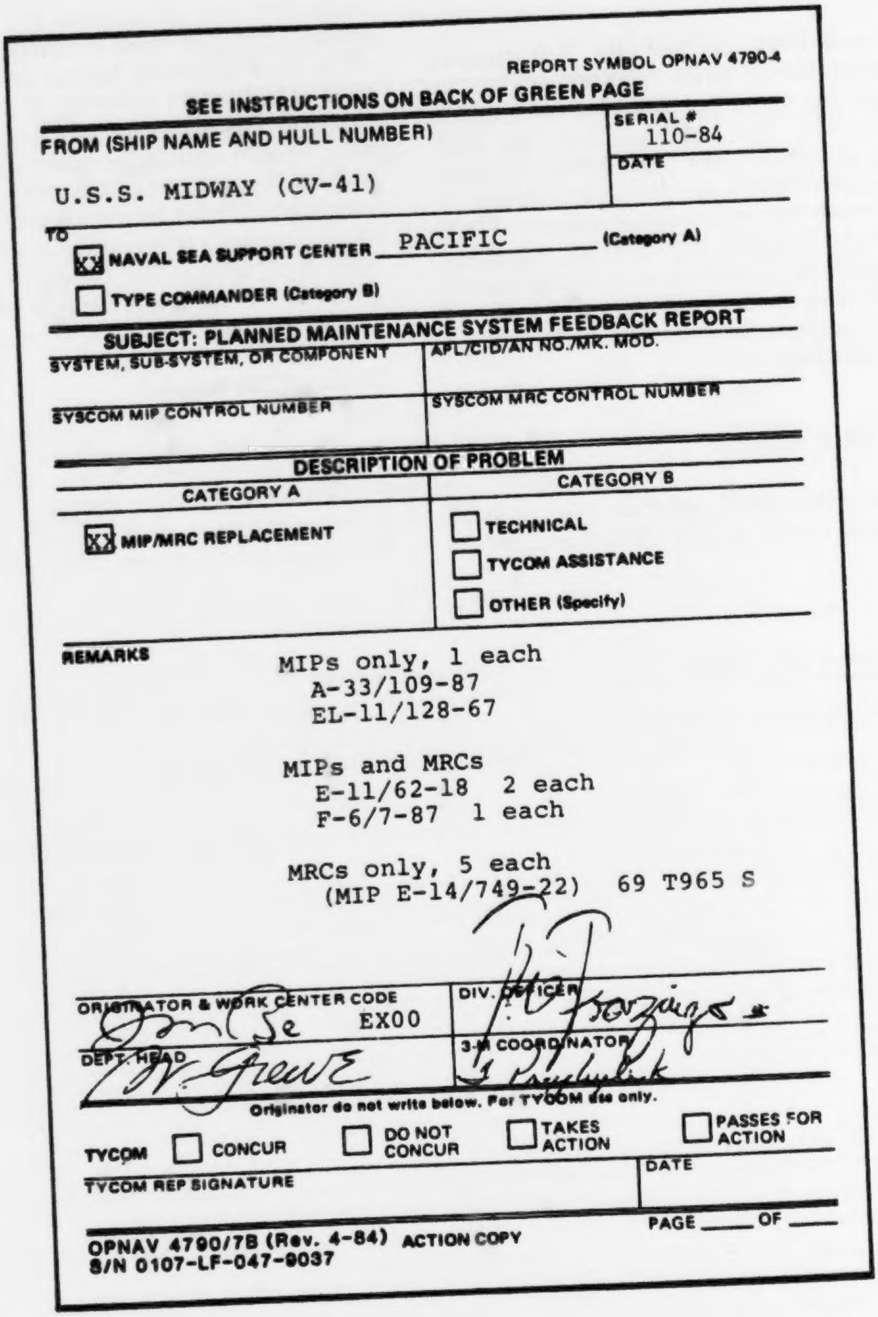
DATE April 1983

N

MAINTENANCE REQUIREMENT CARD (MRC)
OPNAV 4790/82 (REV 2-82)

177.128

Figure 9-5.—Maintenance requirement card (MRC).



REPORT SYMBOL OPNAV 4790-4

SEE INSTRUCTIONS ON BACK OF GREEN PAGE

FROM (SHIP NAME AND HULL NUMBER) U.S.S. MIDWAY (CV-41)	SERIAL # 110-84 DATE

TO

☒ NAVAL SEA SUPPORT CENTER PACIFIC (Category A)

☐ TYPE COMMANDER (Category B)

SUBJECT: PLANNED MAINTENANCE SYSTEM FEEDBACK REPORT

SYSTEM, SUB-SYSTEM, OR COMPONENT	APL/CID/AN NO./MK. MOD.
SYSCOM MIP CONTROL NUMBER	SYSCOM MRC CONTROL NUMBER

DESCRIPTION OF PROBLEM

CATEGORY A	CATEGORY B
☒ MIP/MRC REPLACEMENT	☐ TECHNICAL ☐ TYCOM ASSISTANCE ☐ OTHER (Specify)

REMARKS

MIPs only, 1 each
A-33/109-87
EL-11/128-67

MIPs and MRCs
E-11/62-18 2 each
F-6/7-87 1 each

MRCs only, 5 each
(MIP E-14/749-22) 69 T965 S

ORIGINATOR & WORK CENTER CODE EX00	DIV. OFFICER
DEPT. HEAD W. Greve	3-M COORDINATOR

Originator do not write below. For TYCOM use only.

TYCOM ☐ CONCUR ☐ DO NOT CONCUR ☐ TAKES ACTION ☐ PASSES FOR ACTION

TYCOM REP SIGNATURE	DATE

PAGE ____ OF ____

OPNAV 4790/7B (Rev. 4-84) ACTION COPY
S/N 0107-LF-047-9037

177.129

Figure 9-6.—PMS feedback report.

Cycle PMS Schedule

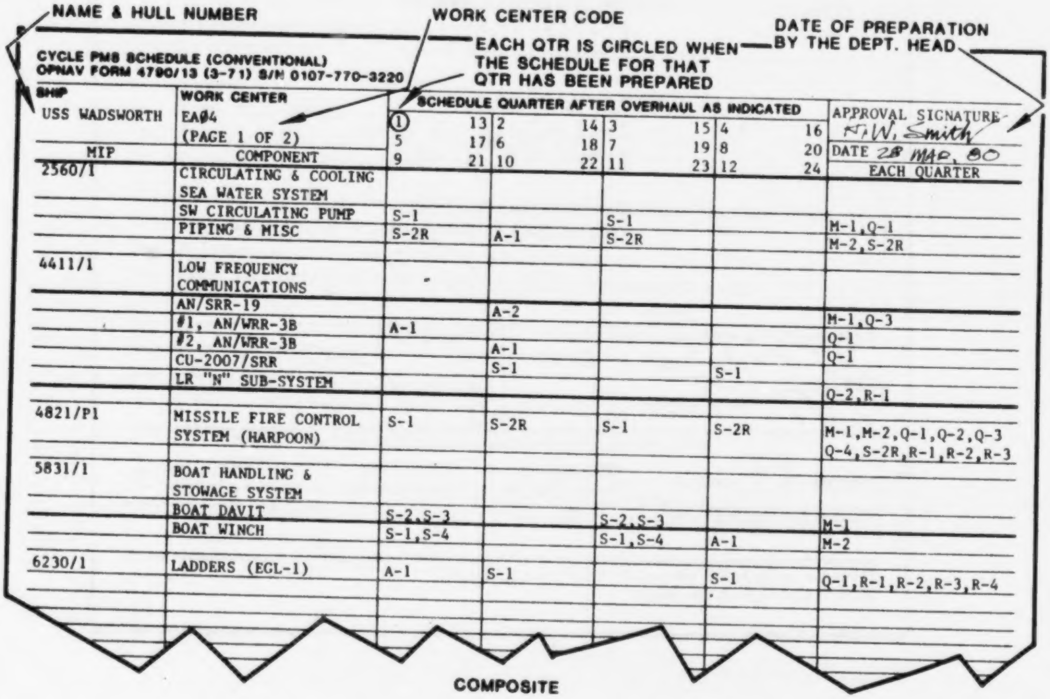
The cycle PMS schedule (fig. 9-7) displays the planned maintenance requirements to be performed by a work center between major overhauls. The cycle schedule lists the MIP numbers, equipment, and periodicities for each task. The periodicities are placed in columns to conform to the four maintenance quarters. When the quarterly schedule is prepared, the maintenance under the current quarter is scheduled as well as all items in the "each quarter" column. Daily and weekly requirements are not shown on the cycle schedule.

Quarterly PMS Schedule

The quarterly PMS schedule (fig. 9-8) is prepared upon receipt of each QFR. The schedule is divided into 13 columns (15 for SSBNs); a column for each week of the quarter or patrol cycle. Each column is further divided into seven days by tick marks at the top of the column. The first tick marked space is Monday, and Monday's date for each week in the quarter is placed on the pedestal between the columns. The quarterly schedule is filled in by the work center supervisor by placing items from the cycle schedule into the week most appropriate for performing the job. Items in the reschedule block of the previous quarterly schedule must also be assigned.

Weekly PMS Schedule

The weekly PMS schedule (fig. 9-9) is prepared by referring to the maintenance on the quarterly schedule for that week. During initial preparation of the weekly schedule, the following block entries are typed or neatly

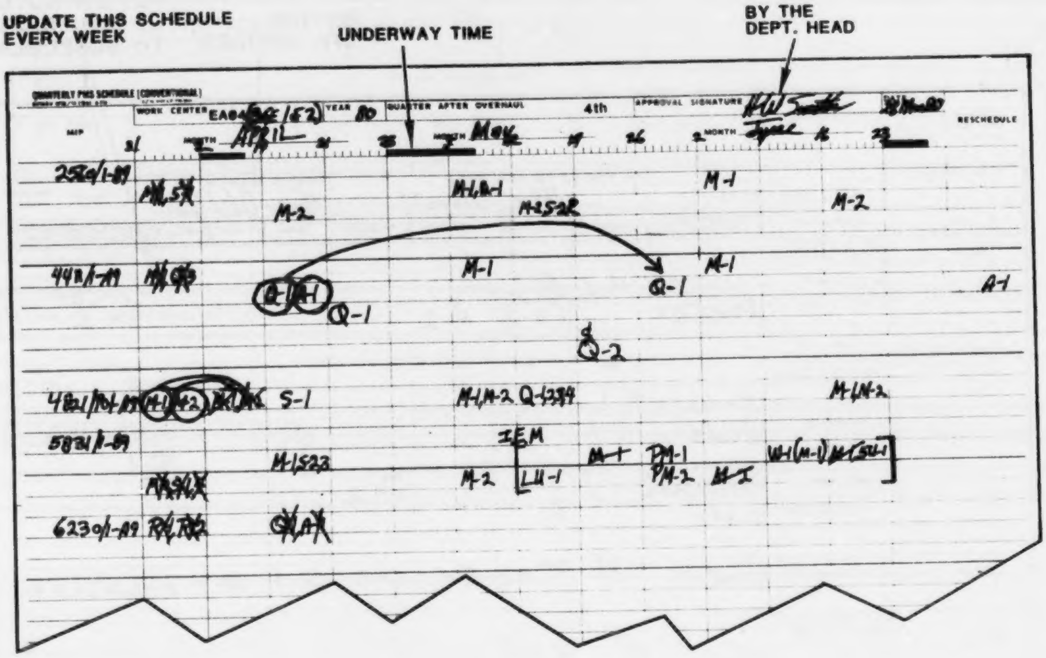

NAME & HULL NUMBER
WORK CENTER CODE
EACH QTR IS CIRCLED WHEN THE SCHEDULE FOR THAT QTR HAS BEEN PREPARED
DATE OF PREPARATION BY THE DEPT. HEAD
COMPOSITE

CYCLE PMS SCHEDULE (CONVENTIONAL)
OPNAV FORM 4790/13 (3-71) S/N 0107-770-3220

SHIP	WORK CENTER	SCHEDULE QUARTER AFTER OVERHAUL AS INDICATED				APPROVAL SIGNATURE N.W. Smith
USS WADSWORTH	EA04 (PAGE 1 OF 2)	① 13 5 17 9 21	2 14 6 18 10 22	3 15 7 19 11 23	4 16 8 20 12 24	DATE 28 MAR. 80
MIP	COMPONENT					EACH QUARTER
2560/1	CIRCULATING & COOLING SEA WATER SYSTEM					
	SW CIRCULATING PUMP	S-1		S-1		M-1,Q-1
	PIPING & MISC	S-2R	A-1	S-2R		M-2,S-2R
4411/1	LOW FREQUENCY COMMUNICATIONS					
	AN/SRR-19		A-2			M-1,Q-3
	#1, AN/WRR-3B	A-1				Q-1
	#2, AN/WRR-3B		A-1			Q-1
	CU-2007/SRR		S-1		S-1	
	LR "N" SUB-SYSTEM					Q-2,R-1
4821/P1	MISSILE FIRE CONTROL SYSTEM (HARPOON)	S-1	S-2R	S-1	S-2R	M-1,M-2,Q-1,Q-2,Q-3 Q-4,S-2R,R-1,R-2,R-3
5831/1	BOAT HANDLING & STOWAGE SYSTEM					
	BOAT DAVIT	S-2,S-3		S-2,S-3		M-1
	BOAT WINCH	S-1,S-4		S-1,S-4	A-1	M-2
6230/1	LADDERS (EGL-1)	A-1	S-1		S-1	Q-1,R-1,R-2,R-3,R-4

177.130

Figure 9-7.—Cycle PMS schedule.


UPDATE THIS SCHEDULE EVERY WEEK
UNDERWAY TIME
BY THE DEPT. HEAD

177.131

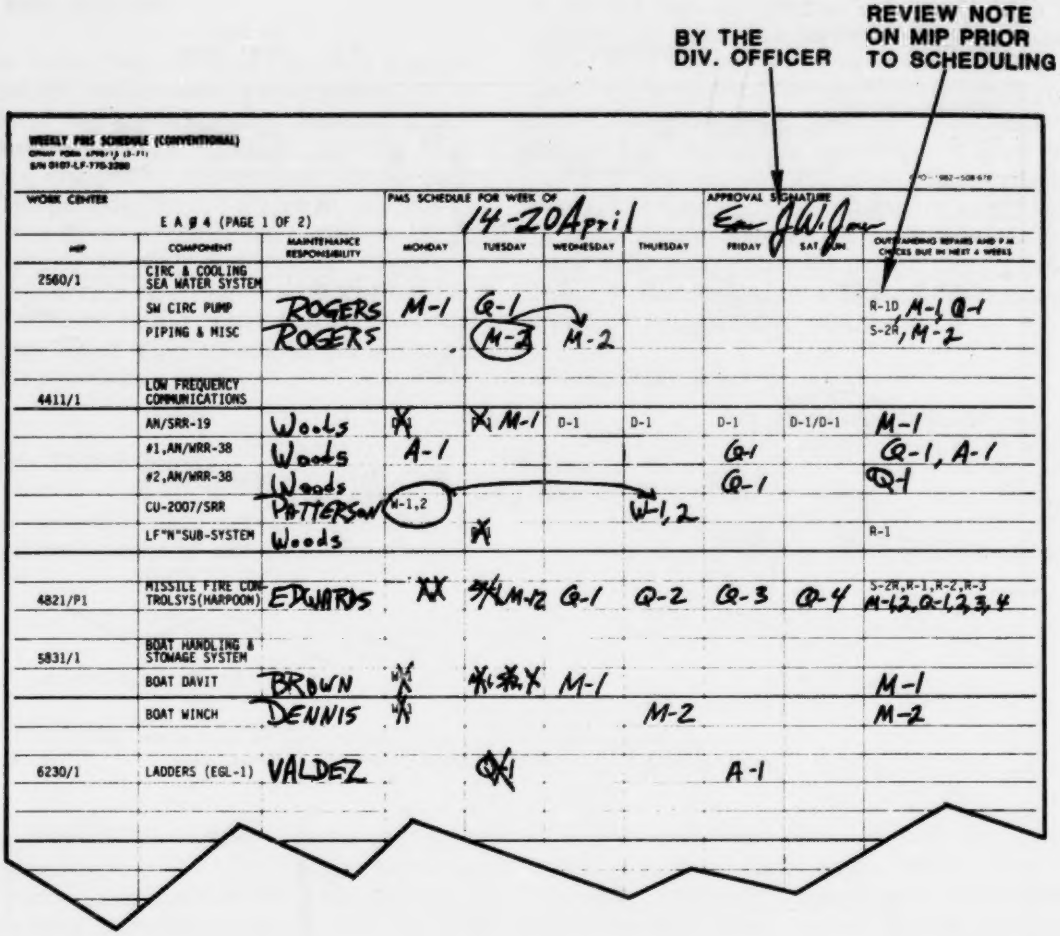
Figure 9-8.—Quarterly PMS schedule.

printed on the schedule: the work center, applicable MIPS, components, and daily and weekly PMS requirements. Situation requirements are entered in the "next four weeks" column. The schedule is then laminated or covered with plastic so it can be updated each week. The person assigned to the job and maintenance requirements are then entered on the lamination at the beginning of each week. The division officer then dates and signs the schedule.

Use of PMS Documentation

The process of correctly completing a maintenance week requires several steps. The first of these is for you to check the weekly schedule to see if you have maintenance assigned for the week. If you do, then you should obtain the applicable MRC card and EGL(s), gather the required items to do the job, and perform the MRC. If you have any problem performing the maintenance exactly as written, you should contact your work center supervisor. If you complete the maintenance, return the MRC to its holder and notify your work center supervisor that the MRC is done. Your supervisor will then update the weekly schedule by marking an "X" through the maintenance item. Maintenance requirements that are not completed (or are partially completed) will be rescheduled by your supervisor.

Each Monday the weekly schedule is used to update the quarterly schedule and a new weekly schedule is prepared. Any requirement not accomplished by the end of the quarter must be identified on the back of the quarterly schedule with a brief explanation. Items such as annual, semiannual, and cycle requirements will be listed in the reschedule block and transferred to the next quarterly schedule. Once the new quarter starts, the old quarterly schedule is retained as a maintenance record for one year.



BY THE DIV. OFFICER

REVIEW NOTE ON MIP PRIOR TO SCHEDULING

WEEKLY PMS SCHEDULE (CONVENTIONAL)
OPNAV FORM 4790/13 (3-71)
S/N 0107-LF-770-3280

GPO : 1982 - 508-678

WORK CENTER E A # 4 (PAGE 1 OF 2)			PMS SCHEDULE FOR WEEK OF 14-20April				APPROVAL SIGNATURE J.W. Jones		
MIP	COMPONENT	MAINTENANCE RESPONSIBILITY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT SUN	OUTSTANDING REPAIRS AND P M CHECKS DUE IN NEXT 4 WEEKS
2560/1	CIRC & COOLING SEA WATER SYSTEM								
	SW CIRC PUMP	ROGERS	M-1	Q-1					R-1D, M-1, Q-1
	PIPING & MISC	ROGERS		M-2	M-2				S-2R, M-2
4411/1	LOW FREQUENCY COMMUNICATIONS								
	AN/SRR-19	Woods	X	X M-1	D-1	D-1	D-1	D-1/D-1	M-1
	#1,AN/WRR-38	Woods	A-1				Q-1		Q-1, A-1
	#2,AN/WRR-38	Woods					Q-1		Q-1
	CU-2007/SRR	PATTERSON	W-1,2			W-1,2			
	LF"N"SUB-SYSTEM	Woods		X					R-1
4821/P1	MISSILE FIRE CONTROLSYS(HARPOON)	EDWARDS	XX	X M-1,2	Q-1	Q-2	Q-3	Q-4	S-2R,R-1,R-2,R-3 M-1,2,Q-1,2,3,4
5831/1	BOAT HANDLING & STOWAGE SYSTEM								
	BOAT DAVIT	BROWN	X	X X X	M-1				M-1
	BOAT WINCH	DENNIS	X			M-2			M-2
6230/1	LADDERS (EGL-1)	VALDEZ		~~Q-1~~			A-1		

177.132

Figure 9-9.—Weekly PMS schedule.

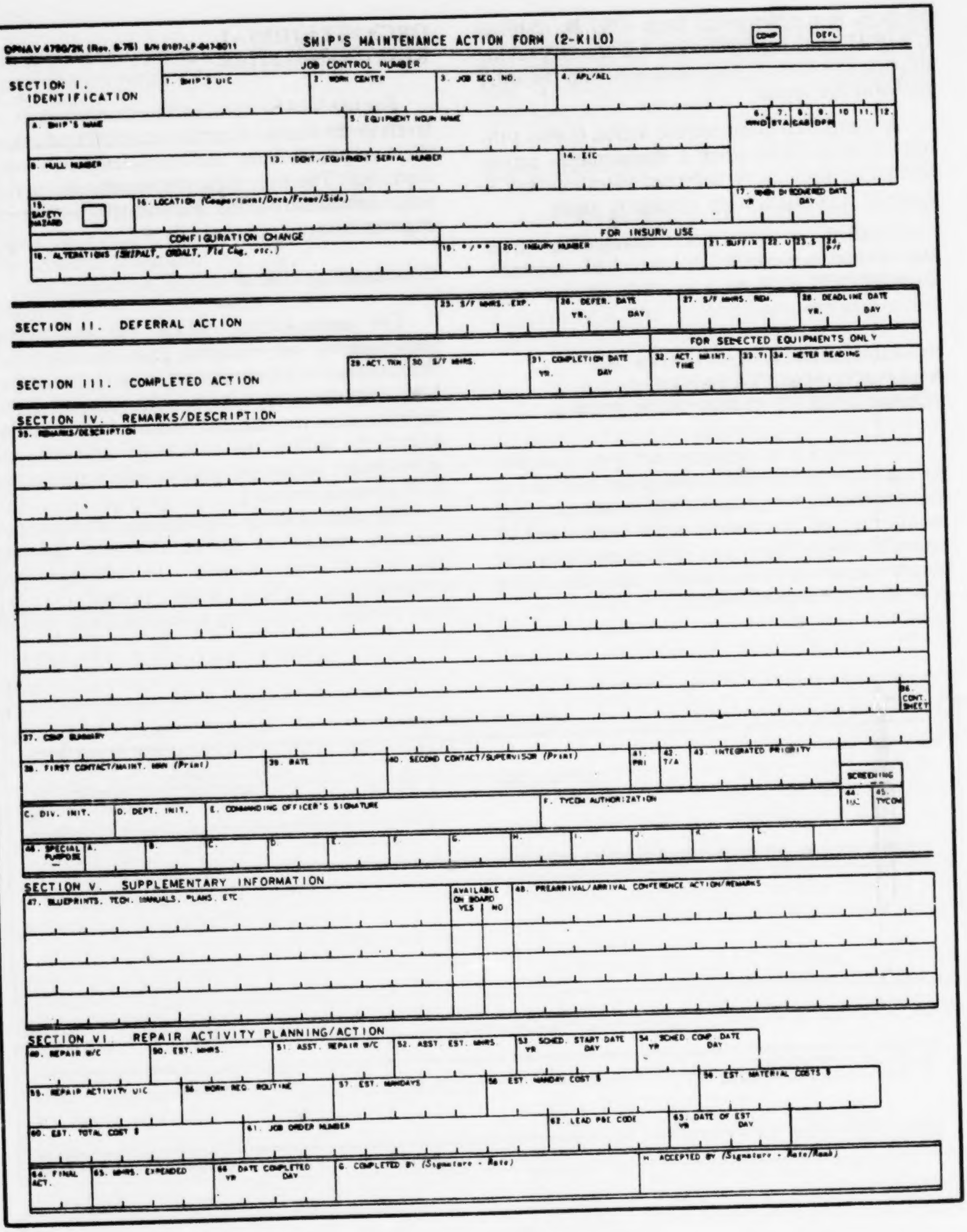
MAINTENANCE DATA COLLECTION SUBSYSTEM (MDCS)

The MDCS provides information about certain fleet maintenance for use by management throughout the Navy. Particular emphasis is on providing information at the shipboard level.

One of the primary functions of the MDCS is to provide a current ship's maintenance project (CSMP) printout, which categorizes and sequences deferred maintenance actions. The CSMP should accurately reflect the material condition of the work center and as such show any limitations of the work center because of equipment malfunctions.

Although the MDCS involves several areas, the areas you will most likely encounter are deferred maintenance actions, completed maintenance actions, and configuration changes.

Deferred maintenance actions are submitted to an intermediate maintenance activity (IMA) on a Ship's Maintenance Action Form 4790.2K (2-kilo) (fig. 9-10). A 2-kilo is submitted when outside assistance is required to perform the maintenance or when the maintenance is not expected to be completed by ship's force within



OPNAV 4790/2K (Rev. 6-75) S/N 0107-LF-047-8011

SHIP'S MAINTENANCE ACTION FORM (2-KILO)

☐ COMP ☐ DEFL

SECTION I. IDENTIFICATION

JOB CONTROL NUMBER

1. SHIP'S UIC
2. WORK CENTER
3. JOB SEQ. NO.
4. APL/AEL
A. SHIP'S NAME
5. EQUIPMENT NOUN NAME
6. WHO
7. STA
8. CAS
9. DFR
10
11.
12.
B. HULL NUMBER
13. IDENT./EQUIPMENT SERIAL NUMBER
14. EIC
15. SAFETY HAZARD ☐
16. LOCATION (Compartment/Deck/Frame/Side)
17. WHEN DISCOVERED DATE YR DAY

CONFIGURATION CHANGE

18. ALTERATIONS (SHIPALT, ORDALT, Fld Chg, etc.)

FOR INSURV USE

19. */**
20. INSURV NUMBER
21. SUFFIX
22. U
23. S
24. P/F

SECTION II. DEFERRAL ACTION

25. S/F MHRS. EXP.
26. DEFER. DATE YR. DAY
27. S/F MHRS. REM.
28. DEADLINE DATE YR. DAY

SECTION III. COMPLETED ACTION

29. ACT. TKN.
30. S/F MHRS.
31. COMPLETION DATE YR. DAY

FOR SELECTED EQUIPMENTS ONLY

32. ACT. MAINT. TIME
33. TI
34. METER READING

SECTION IV. REMARKS/DESCRIPTION

35. REMARKS/DESCRIPTION
36. CONT. SHEET
37. COMP SUMMARY
38. FIRST CONTACT/MAINT. MAN (Print)
39. RATE
40. SECOND CONTACT/SUPERVISOR (Print)
41. PRI
42. T/A
43. INTEGRATED PRIORITY

SCREENING

44. IUC
45. TYCOM
C. DIV. INIT.
D. DEPT. INIT.
E. COMMANDING OFFICER'S SIGNATURE
F. TYCOM AUTHORIZATION
46. SPECIAL PURPOSE A. B. C. D. E. F. G. H. I. J. K. L.

SECTION V. SUPPLEMENTARY INFORMATION

47. BLUEPRINTS, TECH. MANUALS, PLANS, ETC
AVAILABLE ON BOARD YES NO
48. PREARRIVAL/ARRIVAL CONFERENCE ACTION/REMARKS

SECTION VI. REPAIR ACTIVITY PLANNING/ACTION

49. REPAIR W/C
50. EST. MHRS.
51. ASST. REPAIR W/C
52. ASST. EST. MHRS
53. SCHED. START DATE YR DAY
54. SCHED. COMP. DATE YR DAY
55. REPAIR ACTIVITY UIC
56. WORK REQ. ROUTINE
57. EST. MANDAYS
58. EST. MANDAY COST $
59. EST. MATERIAL COSTS $
60. EST. TOTAL COST $
61. JOB ORDER NUMBER
62. LEAD PRE CODE
63. DATE OF EST YR DAY
64. FINAL ACT.
65. MHRS. EXPENDED
66. DATE COMPLETED YR DAY
G. COMPLETED BY (Signature - Rate)
H. ACCEPTED BY (Signature - Rate/Rank)

Figure 9-10.—OPNAV 4790.2K (2-kilo). 177.133

30 days. A supplemental form 4790.2L (2-lima) (fig. 9-11) may be attached to a 2-kilo to provide drawings or lists of items that will help the IMA perform the repair.

A completed maintenance action is also submitted on a 2-kilo when a maintenance action (including previously deferred maintenance) is done or a configuration change is made.

Detailed procedures for completing these forms are contained in the 3-M manual, OPNAVINST 4790.4.

INTERMEDIATE MAINTENANCE ACTIVITY MAINTENANCE MANAGEMENT SUBSYSTEM (IMMS)

The IMMS is a computerized system of procedures used at the IMAs and shore facilities to manage the planning, scheduling, production, and monitoring of the maintenance work load of attached ships. Since you will most likely not become involved with IMMS, only the above general purpose is provided.

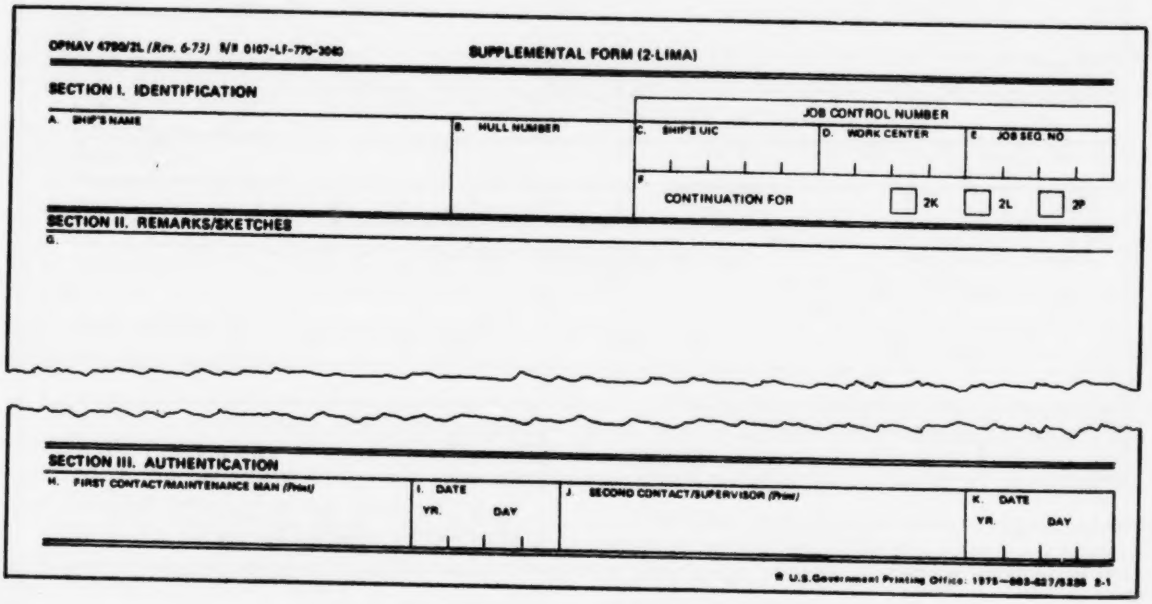
ORGANIZATIONAL RESPONSIBILITIES

For the 3-M Systems to function properly, all levels in the chain of command must understand their responsibilities and conscientiously carry them out. The following paragraphs discuss the responsibilities of the individuals within the organization.

Commanding Officer

The commanding officer has the overall responsibility for ensuring that the shipboard maintenance is accomplished in accordance with 3-M Systems procedures. This responsibility includes ensuring that the 3-M Systems function effectively within the command and that the appropriate personnel receive adequate formal 3-M Systems training.

The commanding officer must also conduct periodic checks to ensure the 3-M Systems are functioning properly. In addition, the commanding officer must ensure that all documentation deferring maintenance to outside



OPNAV 4790/2L *(Rev. 6-73)* S/N 0107-LF-770-3060

SUPPLEMENTAL FORM (2-LIMA)

SECTION I. IDENTIFICATION

		JOB CONTROL NUMBER		
A. SHIP'S NAME	B. HULL NUMBER	C. SHIP'S UIC	D. WORK CENTER	E. JOB SEQ. NO
		F. CONTINUATION FOR ☐ 2K ☐ 2L ☐ 2P		

SECTION II. REMARKS/SKETCHES

G.

SECTION III. AUTHENTICATION

H. FIRST CONTACT/MAINTENANCE MAN *(Print)*	I. DATE YR. DAY	J. SECOND CONTACT/SUPERVISOR *(Print)*	K. DATE YR. DAY

U.S.Government Printing Office: 1975

177.134

Figure 9-11.—OPNAV 4790.2L (2-lima).

activities for assistance is reviewed and approved at a responsible level.

Executive Officer

The executive officer is the ship's 3-M Systems manager and is responsible to the commanding officer for the overall management of the ship's 3-M Systems program.

The executive officer's duties include the following:

1. Be knowledgeable of current ship's 3-M Systems policies and directives
2. Monitor the operation of the 3-M Systems program to ensure compliance with current directives
3. Integrating 3-M Systems training into the ship's training program and ensuring that personnel receive adequate and effective 3-M Systems training

3-M Coordinator

The ship's 3-M Systems coordinator is responsible to the executive officer for the coordination and direct supervision of all administrative aspects of the 3-M Systems program. This position will be assigned in writing as the primary duty or most important collateral duty of an officer or senior petty officer.

The 3-M Systems coordinator's duties include the following:

1. Serving as the principal 3-M Systems assistant to the executive officer
2. Ensuring that the ship's 3-M Systems installation is kept current; also ensuring that distribution of Quarterly Force Revisions (QFRs) and special issue PMS documentation is made to work center personnel on a timely basis
3. Advising and assisting department heads, division officers, departmental 3-M assistants, and work center supervisors in matters concerning 3-M Systems; keeping these people informed of changes as they occur
4. Monitoring departmental administration of the 3-M Systems on a continuing basis
5. Supervising the functions of the 3-M Systems office
6. Screening MDS documents for legibility and completeness and submitting them within four working days of receipt to the designated data processing activity

Department Head

Department heads are responsible for the effective operation of the 3-M Systems within their respective departments. The department head supervises all cycle and quarterly scheduling of departmental 3-M Systems functions and carries out the following duties:

1. Regularly inspects the 3-M Systems operation within the department, including a weekly review of PMS schedules to ensure that they are current
2. Ensures that departmental personnel are properly trained and motivated concerning the 3-M Systems
3. Ensures that departmental 3-M files and publications are current and properly maintained
4. Conducts periodic meetings with division officers and work center supervisors and keeps the executive officer informed of the status of 3-M Systems within the department
5. Provides guidance to division officers and work center supervisors on 3-M Systems matters
6. Signs cycle and quarterly schedules prior to posting
7. Ensures that all reported material deficiencies are promptly documented on a ship's force work list or the CSMP
8. Ensures that all required 3-M Systems documents are submitted to the 3-M Systems coordinator within four working days of the date of origination
9. Ensures that 3-M Systems reports and summaries are properly distributed, validated, and used (this pertains particularly to CSMP reports)

Departmental Assistant

The department head should assign an officer or petty officer who is knowledgeable in the 3-M Systems as the departmental assistant. This person provides assistance in the coordination and supervision of all administrative aspects of the department's 3-M Systems program.

Division Officer

The division officer is responsible to the department head and must be trained in the 3-M Systems. The division officer assists in managing the maintenance required for the equipment within the division. The division officer must also:

1. Ensure that qualified senior personnel review the MIPs and MRCs to determine if the maintenance requirements (MRs) are complete, applicable, and correct
2. Supervise the preparation of the weekly schedules and sign them
3. Perform spot checks at least weekly to ensure that required maintenance is being performed properly
4. Ensure that the department's quarterly schedule is updated weekly
5. Incorporate 3-M Systems training into the divisional training plan
6. Ensure that documents generated in the division are complete, accurate, and promptly submitted
7. Ensure that the divisional 3-M Systems files, publications, MRC decks, and EGLs are complete and current

Work Center Supervisor

The senior petty officer within the work center is the work center supervisor and is responsible for the effective operation of the 3-M Systems within the work center. This responsibility may not be delegated to subordinate maintenance personnel. The work center supervisor must receive 3-M Systems training and be responsible for the following:

1. Scheduling weekly work center maintenance and supervising its proper accomplishment
2. Ensuring that the status of work center planned maintenance is correctly reflected on the PMS schedules
3. Ensuring that the division officer is advised of all 3-M Systems activities within the work center
4. Ensuring prompt documentation of all noted material deficiencies
5. Promptly documenting completed maintenance action on OPNAV 4790.2K forms when required
6. Ensuring that all 3-M Systems documents submitted from the work center are correct, legible, and promptly submitted
7. Maintaining control and accountability of job sequence numbers (JSNs) within the work center
8. Verifying that the current ship's maintenance project (CSMP) is complete
9. Reviewing maintenance requirement cards (MRCs) and promptly submitting an FBR as required
10. Maintaining an accurate and current List of Effective Pages (LOEP) by comparing the documentation with the actual equipment configuration in the work center
11. Ensuring the maintenance requirement (MR) is accomplished in strict accordance with the MRC

Maintenance Personnel

Maintenance personnel (you) are responsible to the work center supervisor. Your 3-M Systems duties include, but are not limited to, the following:

1. Reading the weekly schedule
2. Performing assigned scheduled maintenance in accordance with MRCs and EGLs
3. Promptly notifying your work center supervisor whenever:

    a. Any part on an MRC is not fully understood or appears to be incorrect
    b. Tools, material, and so forth, prescribed by the MRC are not available
    c. Any doubt exists about your capability to properly perform the MR
    d. Factors exist which would make performance of the MR unwise or dangerous
    e. Equipment deficiencies or casualties are discovered

4. Informing the work center supervisor when you have completed planned maintenance requirements and of any problems encountered in doing them

5. Notifying the work center supervisor of the important details of any corrective maintenance action so that the maintenance may be documented if necessary

6. Filling out maintenance action documents

SUPPLY

When your equipment becomes inoperative or must operate in a reduced capacity, you must usually obtain a replacement part to restore it. The replacement part may be a ready spare or one received from the supply department.

What must you do to obtain the materials you require from the supply department? What forms are required to requisition the materials? As a petty officer, you should be able to answer these questions. Also, as a petty officer, you may be responsible for requisitioning the required materials for your division. The purpose of this section is to help you become familiar with how the supply system operates.

By understanding how the system operates, you can use the Navy Supply System and perform your duties more effectively.

This section is not meant to make you an expert in supply matters. Rather, it is designed to give you a basic understanding of supply procedures to improve your abilities.

MATERIAL IDENTIFICATION

The Department of Defense Supply System stocks over four million supply items. The Navy Supply System alone stocks over one million items. Because of this, the Federal Catalog System was developed. It ensures the proper requisitioning of items from either an activity ashore or from a unit of the mobile logistics support force.

The Federal Catalog System is responsible for naming, describing, classifying, and numbering all items carried under centralized inventory control by the Department of Defense and the civil agencies of the federal government. Only one identification may be used for each item in all supply functions from purchase to final disposal.

This system also serves as an economy measure. Instead of the Army, Navy, Air Force, and civil agencies each purchasing and maintaining large stocks of material, all agencies can make use of centralized stocks. The Federal Catalog System also is used by North Atlantic Treaty Organization (NATO) countries.

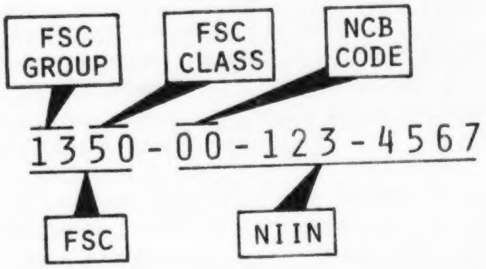
STOCK AND CONTROL NUMBERS

Four types of stock and control numbers are used to identify and order material in the supply system. The identification numbers are known as national stock numbers, NATO stock numbers, Navy item control numbers, and local item control numbers. A definition and description of the types of stock and control numbers are stated in the following paragraphs.

National Stock Numbers

National stock numbers (NSNs) are the most common identification numbers used to identify material. An NSN is a 13-digit number consisting of a 4-digit federal supply classification (FSC) code number and a 9-digit national item identification number (NIIN). Figure 9-12 illustrates a typical NSN format.

The federal supply classification (FSC) code number identifies an item by commodity or description. The first two digits of the FSC are called the FSC group, and the last two digits of the FSC are called the FSC class. The first two digits (for example, 53) denote the group or major division of commodities; the last two digits (for example, 05, 06) denote the class or



177.135

Figure 9-12.—National stock number format.

subdivision of commodities within a group. An example of the FSC system is as follows:

GROUP 53	
Hardware and abrasives	5305—Screws 5306—Bolts 5307—Studs 5310—Nuts and washers 5320—Rivets

The national item identification number (NIIN) identifies each item of supply used by the Department of Defense (DOD) and the North Atlantic Treaty Organization (NATO). The NIIN relates to identification data that makes an item of supply different (as far as DOD is concerned) from every other item of supply. The amount and type of identification data depend on the item and its intended use. Although the NIIN is part of the national stock number (NSN), it is used independently to identify an item. Except for identification lists, most federal supply catalogs are arranged in NIIN order.

NATO Stock Number

A NATO agreement provided for the adoption of the United States NSN system as the basis for the NATO item identification system. A NATO stock number is identical to an NSN with the exception of the national codification bureau (NCB) code. The NCB code either identifies the country that assigned the stock number or indicates that the stock number is used by two or more countries. The NCB code numbers 00 and 01 indicate the United States.

Navy Item Control Numbers

Items of material that are not included in the Federal Catalog System, but which are stocked or monitored in the Navy Supply System, are identified by Navy item control numbers (NICNs). NICNs are 13-character item identification numbers used for permanent or temporary control of selected non-NSN items. An NICN consists of four numerics in the first four positions; then a two-position alpha code (NICN code) that identifies the type of NICN; and then seven digits or alphanumerics which, in conjunction with the NICN code, uniquely identify each NICN item in the Navy Supply System. Some examples of NICNs are as follows:

NICN Code	Application	Examples
LF	Cog I stock numbers for forms	0108-LF-504-2201
LK	Aircraft change kit numbers	1234-LK-YA1-2345
LP	Cogs OI and OP stock numbers for publication	0530-LP-485-0000

Local Item Control Numbers

Local item control numbers (formerly called local stock numbers) may be assigned by local supply activities for consumable items which are not identified by an NSN, a NATO stock number, or an NICN. Locally assigned item control numbers are authorized for local use only (that is, for shipboard stock records, locator records, bin tags, and issue documents). The numbers are not authorized to be used in requisitions because they would be meaningless within the supply system.

COGNIZANCE SYMBOLS

A cognizance (cog) symbol is a two-character, alphanumeric code (for example, 1H, 2T, 6T, and 9Z). This symbol identifies and designates the cognizant inventory manager who exercises supply management over specific categories of material. Although not part of the stock number, the cognizance symbol may be prefixed to the stock number in some supply publications and allowance listings (for example, 2T1350-00-123-4567). However, the cognizance symbol is not prefixed to the stock number on supply documents, forms, or records.

The first numeric character of the cognizance symbol denotes the stores account of the item. Briefly, the numerical characters indicate the following:

1, 3, 5, 7	Material is held in the Navy Stock Account (NSA). When this material is issued, it must be paid for by the requisitioner.

9	Material purchased by the Defense Stock Fund and held in NSA. When this material is issued, it must be paid for by the requisitioner.
2, 4, 6, 8	Material held in the Appropriations Purchases Account (APA) or nonstores account, which is issued without charge to the requisitioner.
0	Material is not in a stores account, but is issued without charge to the requisitioner.

The second character (letter), in conjunction with the first numeric character, identifies the specific inventory control point, office, or agency that controls the issuance of the material.

SPECIAL MATERIAL IDENTIFICATION CODE (SMIC)

Special material identification codes (SMICs) are assigned to certain items to ensure their technical integrity. Because of the nature of these items, they have stricter requirements regarding procurement, issue and receipt, inspections, tests, storage, and handling. An example would be items specially designed, manufactured, and tested for use in nuclear reactor plants, which require special handling, machining, and so forth, prior to being installed and used.

An SMIC is a 2-digit alpha or alphanumeric code (for example, 5330-00-010-4960-X3). The SMICs currently authorized are listed and explained in NAVSUP Pub 485, Appendix 9.

NOMENCLATURE

As part of the Federal Catalog System, each item of supply is assigned an official government name. Personnel frequently refer to material by trade names or common terms rather than the official name. Referring to an item by its common term is not wrong. However, only the official name of an item should be used when requisitioning supplies.

OTHER SOURCES OF IDENTIFICATION DATA

Let us assume that you do not have a stock number for an item and cannot locate it in the allowance lists. You then have two primary sources of information for identifying the item: (1) other identification data relating to the item itself and (2) identification publications in which available data are recorded and used.

If you can find other identification data, such as reference numbers for the item, your supply department may be able to locate the correct national stock number. A reference number may be a part, type, catalog, or drawing number; or it may be a specification or nomenclature designation that the manufacturer, contractor, or governmental agency has applied to the item. A superseded stock number is also a type of reference number. One of the most important sources of identification is the information on nameplates. This may include manufacturer's name, make, or model number; size; voltage; and the like. Identification publications, such as manufacturer's technical manuals, may also help you in identifying an item.

Manufacturer's Part Numbers

Commercial catalogs and instruction booklets issued by manufacturers contain valuable information that you should use in preparing procurement documents for nonstandard material. You should use these catalogs and booklets as supplements to Navy publications to identify commercial equipment, repair parts, and accessories accurately.

Serial Numbers

Certain technical material may be serially numbered, either by direction of the responsible bureau or systems command or by the manufacturer. These serial numbers are used in maintaining records on the material and appear on all vouchers, records, custody cards, and survey reports.

Nameplates

Material identification, particularly portable and installed equipment, is made easier by referring to nameplates attached to the equipment. Nameplate data includes the manufacturer's name, and the equipment make or model number, serial number, size, voltage, and the like.

Drawing Numbers

Certain technical material may be identified only by a drawing or sketch number. These numbers may be assigned by the manufacturer, controlling bureau, or systems command. When you are requisitioning nonstandard items, the drawing number, if available, must be included to aid in positive identification.

Markings

Various items of electronic equipment are identified by Joint Electronics Type Designations (JETDs) nomenclature (for example, AN/UYK-5(V)), Navy type or model number, and manufacturer's model number, as well as stock number and serial number.

SUPPLY PUBLICATIONS

When you turn in a requisition for supplies, you set in motion a long chain of events involving movement of materials, maintaining stock records, and procurement actions. Because of this chain of events, you (the requisitioner) must supply accurate information to ensure prompt results from the requisition.

The Management List-Navy (ML-N) and several related publications are designed to provide you information for submitting accurate and error free requisitions. The format and use of these publications are described in the *Introduction to the Federal Supply Catalogs and Related Publications,* NAVSUP P-4000. These publications are used primarily by the supply department. However, as a divisional supply petty officer, you may have an occasional need for information contained in them. Because of this, a short description of these publications is provided for you.

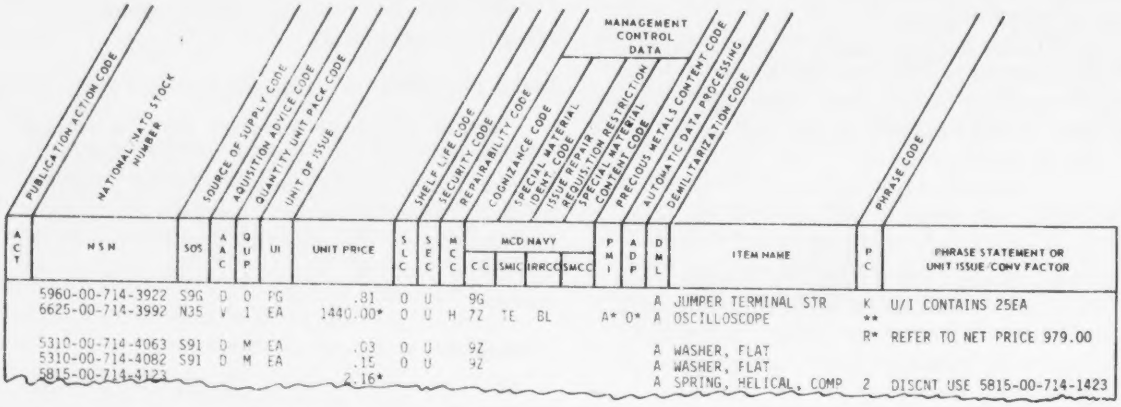
Management List-Navy (ML-N)

The Management List-Navy (ML-N) contains basic management data necessary for preparing requisitions. This data includes stock number changes, units of issue, unit prices, and associated information. (See figure 9-13.)

The ML-N is published in microfiche form, and a complete revision is distributed quarterly. It includes an integrated historical record of deleted and superseded NIINs and has appropriate phrase codes to indicate disposition action. The ML-N provides other data of importance; namely whether an item is a mandatory turn-in item, whether it is OPTAR (Operating Target) funded, and if so, the net cost (with turn-in) or unit cost (without turn-in).

Master Cross-Reference List (MCRL)

The Master Cross-Reference List (MCRL), NAVSUP P-4300, provides cross-reference from a reference number (manufacturer's part number, drawing number, design control number, and so


PUBLICATION ACTION CODE
NATIONAL NATO STOCK NUMBER
SOURCE OF SUPPLY CODE
AQUISITION ADVICE CODE
QUANTITY UNIT PACK CODE
UNIT OF ISSUE
SHELF LIFE CODE
SECURITY CODE
REPAIRABILITY CODE
COGNIZANCE CODE
MANAGEMENT CONTROL DATA
SPECIAL MATERIAL IDENT. CODE
ISSUE REPAIR REQUISITION RESTRICTION
SPECIAL MATERIAL CONTENT CODE
PRECIOUS METALS CONTENT CODE
AUTOMATIC DATA PROCESSING
DEMILITARIZATION CODE
PHRASE CODE

ACT	NSN	SOS	AAC	QUP	UI	UNIT PRICE	SLC	SEC	MCC	MCD NAVY				PMI	ADP	DML	ITEM NAME	PC	PHRASE STATEMENT OR UNIT ISSUE/CONV FACTOR
										CC	SMIC	IRRCC	SMCC						
	5960-00-714-3922	S9G	D	0	PG	.81	0	U		9G						A	JUMPER TERMINAL STR	K	U/I CONTAINS 25EA
	6625-00-714-3992	N35	V	1	EA	1440.00*	0	U	H	7Z	TE	BL		A*	0*	A	OSCILLOSCOPE	**	
																		R*	REFER TO NET PRICE 979.00
	5310-00-714-4063	S91	D	M	EA	.03	0	U		9Z						A	WASHER, FLAT		
	5310-00-714-4082	S91	D	M	EA	.15	0	U		9Z						A	WASHER, FLAT		
	5815-00-714-4123					2.16*										A	SPRING, HELICAL, COMP	2	DISCNT USE 5815-00-714-1423

63.51

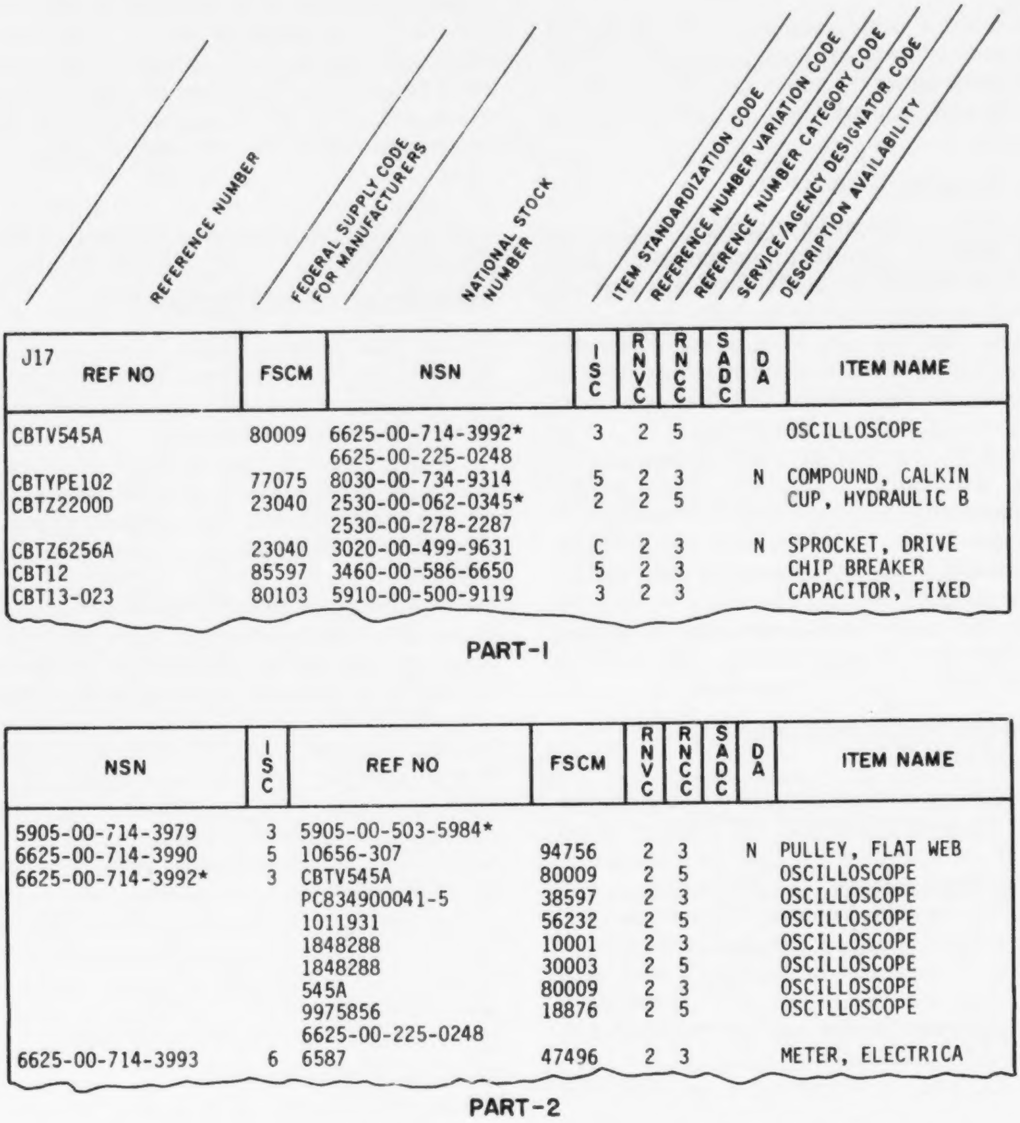
Figure 9-13.—Management List-Navy (ML-N).

forth) to its assigned NSN. (See figure 9-14.) The MCRL also provides cross-reference from an NSN to a reference number.

Master Repairable Item List (MRIL)

The Navy's Master Repairable Item List (MRIL), NAVSUP P-4107, is provided to identify Navy-managed mandatory turn-in repairable items. It also provides shipping instructions for unserviceable repairables that must be turned in to a designated repair facility.

Two basic parts are included in the MRIL: Part I—Listing of Items and Part II—Shipping Addresses. Part I is a list, in NIIN sequence, of


REFERENCE NUMBER
FEDERAL SUPPLY CODE FOR MANUFACTURERS
NATIONAL STOCK NUMBER
ITEM STANDARDIZATION CODE
REFERENCE NUMBER VARIATION CODE
REFERENCE NUMBER CATEGORY CODE
SERVICE/AGENCY DESIGNATOR CODE
DESCRIPTION AVAILABILITY

J17 REF NO	FSCM	NSN	ISC	RNVC	RNCC	SADC	DA	ITEM NAME
CBTV545A	80009	6625-00-714-3992* 6625-00-225-0248	3	2	5			OSCILLOSCOPE
CBTYPE102	77075	8030-00-734-9314	5	2	3		N	COMPOUND, CALKIN
CBTZ2200D	23040	2530-00-062-0345* 2530-00-278-2287	2	2	5			CUP, HYDRAULIC B
CBTZ6256A	23040	3020-00-499-9631	C	2	3		N	SPROCKET, DRIVE
CBT12	85597	3460-00-586-6650	5	2	3			CHIP BREAKER
CBT13-023	80103	5910-00-500-9119	3	2	3			CAPACITOR, FIXED

PART-I

NSN	ISC	REF NO	FSCM	RNVC	RNCC	SADC	DA	ITEM NAME
5905-00-714-3979	3	5905-00-503-5984*						
6625-00-714-3990	5	10656-307	94756	2	3		N	PULLEY, FLAT WEB
6625-00-714-3992*	3	CBTV545A	80009	2	5			OSCILLOSCOPE
		PC834900041-5	38597	2	3			OSCILLOSCOPE
		1011931	56232	2	5			OSCILLOSCOPE
		1848288	10001	2	3			OSCILLOSCOPE
		1848288	30003	2	5			OSCILLOSCOPE
		545A	80009	2	3			OSCILLOSCOPE
		9975856	18876	2	5			OSCILLOSCOPE
		6625-00-225-0248						
6625-00-714-3993	6	6587	47496	2	3			METER, ELECTRICA

PART-2

245.98

Figure 9-14.—Master Cross-Reference List (MCRL).

all repairables that are no longer serviceable and disposition instructions. Usually, unserviceable components are shipped to a designated repair facility/collection point. Part I also lists the shipping code of the activity to which an unserviceable repairable must be shipped. Part II lists the shipping addresses of designated repair activities (military and civilian contractors) and collection points to which the repairables are to be sent.

As a work center supervisor or divisional supply petty officer, you must cooperate with the supply department by returning replaced parts. By doing this, you will help to use fleet assets efficiently.

Afloat Shopping Guide (ASG)

The *Afloat Shopping Guide* (ASG) is another source used for identification purposes. It is designed to assist fleet and Navy supply support personnel in identifying to an NSN those items of supply that do not have a part/reference number. Descriptions and illustrations may be used to determine substitutions and applicable NSNs in the general hardware area.

The ASG consists of seven volumes containing descriptive data and illustrations, accompanied by alphabetic and NIIN indexes of the groups/classes. The NIIN index also indicates the availability of an item from the mobile logistics support forces. The ASG is updated annually and each volume is reissued in its entirety every fourth year. A page from the ASG is shown in figure 9-15.

Coordinated Shipboard Allowance List (COSAL)

The Coordinated Shipboard Allowance List (COSAL) is both a technical and a supply document. It is technical in that nomenclature, operating characteristics, technical manuals, and so forth, are described on Allowance Parts Lists (APLs) and Allowance Equipage Lists (AELs). It is a supply document in that the COSAL provides a complete list of all parts required to operate and maintain the equipment installed in all ship/shore activities.

The COSAL is prepared for an individual ship/shore activity and lists (1) the equipment or components required for the ship/activity to perform its operational assignment; (2) the repair parts and special tools required for the operation, overhaul, and repair of these equipments; and (3) the miscellaneous portable items necessary for the care and upkeep of the ship/activity itself.

The COSAL is based on equipment configuration data contained in the computerized Weapons System File (WSF) at the Ship Part Control Center (SPCC). The WSF includes the equipment configuration reported to be installed on each ship as well as the individual repair parts applicable to those equipments. Configuration information for the COSAL must be precise. Therefore, the initial establishment of a configuration data base must be accurate. Thereafter, changes which result from additions, deletions, or modifications of equipment must be reported promptly. The quality of the COSAL is only as good as the equipment configuration data available to the various activities involved in the development of the COSAL.

MATERIAL PROCUREMENT

Once you have determined that a replacement part is required and you have the NSN of the part, you are ready to order the part. In the Navy, this process is called procurement.

Procurement is the process of obtaining materials and services to support the operation of an activity. The two basic methods of procurement in the Navy are by requisition and by purchase.

As a divisional supply petty officer or perhaps as a work center supervisor, you will play an important role in the procurement of materials and services. If you are in one of these positions, you will be required to decide the necessity of material requested by the work center supervisors in your division or by your own subordinates. You must also know if the material is authorized for use by your command, division, or work center. In addition, you must determine the importance of the material over other material and properly assign a priority designation. As a supply petty officer or work center supervisor, you will be the principal advisor to your division leading chief petty officer and division officer on all matters of procurement at the divisional level.

MILITARY STANDARD REQUISITIONING AND ISSUE PROCEDURE (MILSTRIP)

A requisition is a request for materials or services. The most common method of

1

2

Specification Data–MIL-R-94

TYPE	TAPER	WATTS	BUSHING SIZE	SHAFT DIA.	BODY DIM.	FIG
RV2	A	1	3/8-32	1/4	.64 x .42	1
RV2	C	1/2	3/8-32	1/4	.64 x .42	1
RV4	A	2	3/8-32	1/4	.90 x .45	1
RV4	C, F	1	3/8-32	1/4	.90 x .45	1
RV5	A	1/2	1/4-32	1/8	.75 x .37	1
RV6	A	1/2	1/4-32	1/8	.50 x .37	2
RV6	C, F	1/4	1/4-32	1/8	.50 x .37	2

1 WATT

Locking bushing, 5/8 in. lg shaft.

	Ohms	Mil Type RV2LAYSA
00-815-5498	10K	103A

Standard bushing, 7/8 in. lg shaft.

	Ohms	Mil Type RV2N
00-835-8870	1.5K	AYSD152A
00-577-6803	10K	AYSD103A
00-964-6059*	10K	BYSD103A
00-853-0798	100K	AYSD104A

*With SPST switch.

2 WATT

Locking bushing, 5/8 in. lg shaft.

	Ohms	Mil Type RV4LAYSA
00-681-8688	50	500A
00-503-5984	100	101A
00-503-6218	250	251A
00-539-4897	500	501A
00-646-5958	1K	102A
00-539-2567	2.5K	252A
00-539-2479	5K	502A
00-518-5595	10K	103A
00-501-7314	25K	253A
00-501-5184	50K	503A
00-665-4992	100K	104A
00-552-2093	250K	254A
00-518-5593	500K	504A
00-518-5609	1MEG	105A
00-552-5487	5MEG	505A

Locking bushing, 7/8 in. lg shaft.

	Ohms	Mil Type RV4LAYSD
00-577-3717	2.5K	252A
00-577-3645	25K	253A
00-556-3042	100K	104A
00-023-7931	1MEG	105A

Standard bushing, 1/2 in. lg shaft.

	Ohms	Mil Type RV4NAYSB
00-542-8046	1K	102A
00-646-5957	10K	103A
00-646-5981	25K	253A
00-643-6284	50K	503A
00-542-8048	100K	104A
00-542-8051	1MEG	105A

Standard bushing, 7/8 in. lg shaft.

	Ohms	Mil Type RV4NAYSD
00-556-3041	100	101A
00-552-2859	500	501A
00-552-5478	1K	102A
00-577-9976*	1K	
00-539-5013	2.5K	252A
00-643-5626	5K	502A
00-578-4471	7.5K	752A
00-556-3350	10K	103A
00-552-5479	15K	153A
00-539-1559	25K	253A
00-539-4900	50K	503A
00-644-6693	100K	104A
00-552-5476	250K	254A
00-893-9499	500K	504A
00-501-7307	1.5MEG	155A
00-655-3312	2MEG	205A

*With SPST switch, MIL Spec type RV4NBYSD102A.

Standard bushing, 1-1/4 in. lg-shaft.

	Ohms	Mil Type RV4NAYSG
00-811-1750	2.5K	252A

Standard bushing, 2-1/2 in. lg shaft.

	Ohms	Mil Type RV4NAYSK
00-539-4999	100	101A
00-539-2568	250	251A
00-557-4637	500	501A
00-500-7588	1K	102A
00-542-8724	2.5K	252A
00-666-1036	5K	502A
00-665-5095	10K	103A
00-581-2846*	10K	
00-500-7879	25K	253A
00-542-8744	50K	503A
00-339-4576	100K	104A
00-539-4578	250K	254A
00-539-4998	500K	504A
00-552-2254	1MEG	105A

*With SPST switch, MIL Spec type RV4NBYSK103A

C TAPER

1/4 WATT

Standard bushing, 7/8 in. lg shaft.

	Ohms	Mil Type RV5NAYSD
00-802-7951	5K	502C

	Ohms	Mil Type RV6NAYSD
00-851-5648	5K	502C
00-954-4038	10K	103C

1 WATT

Locking bushing, 7/8 in. lg shaft.

	Ohms	Mil Type RV4LAYSA
00-578-9051	1MEG	105C

Standard bushing, 7/8 in. lg shaft.

	Ohms	Mil Type RV4NAYSD
00-681-6172	500	501C
00-552-3480	10K	103C

Standard bushing, 7/8 in. lg. (Shaft and panel sealed.)

	Ohms	Mil Type RV4SAYSD
00-542-9406	500	501C

Standard bushing, 2-1/2 in. lg shaft.

	Ohms	Mil Type RV4NAYSK
00-553-9970	2.5K	252C
00-578-4134	50K	503C

F TAPER

1/4 WATT

Locking bushing, 5/8 in. lg shaft.

	Ohms	Mil Type RV6LAYSA
00-752-3377	50K	503E

1 WATT

Locking bushing, 5/8 in. lg shaft.

	Ohms	Mil Type RV4LAYSA
00-683-5996	10K	103E

INDUSTRIAL TYPE. A taper. Fully inclosed body with 1/4 in. diameter slotted shaft and mounted by a 3/8 - 32 thread bushing.

Single section
2-1/4 Watt at 70 deg C, body dimension. 11/16 in. lg x 1-5/32 in. diameter, 1-7/16 in. lg shaft, panel sealed bushing, 3 solder lug terminals.

00-482-4992 350 OHMS 10% tol

3 Sections

2 Watt at 70 deg C, body dimension. 1-29/32 in. lg x 1-5/32 in. diameter, 5/8 in. lg shaft, 9 solder lug terminals.

00-264-7818 2.5 meg, 2.5 meg, 20%, 25K, 10%

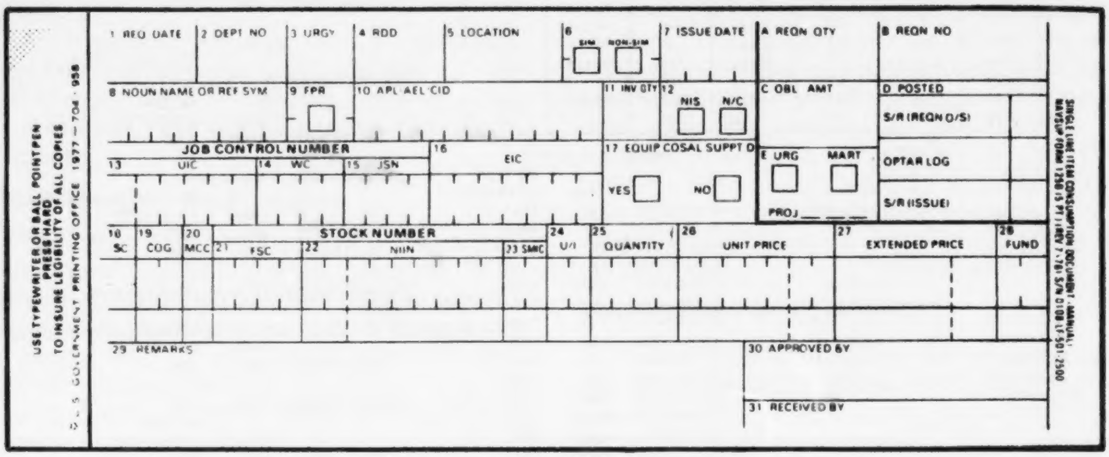
123.138

Figure 9-15.—Page from Afloat Shopping Guide (ASG).

requisitioning materials is through a DOD system known as the Military Standard Requisitioning and Issue Procedure (MILSTRIP).

As the name implies, MILSTRIP is used for the requisitioning and issuing of materials. Many transactions are sometimes necessary between the time a requisition is submitted and the material is received. Some of these transactions include the furnishing of supply status information, follow-up requests, redistribution orders, referral orders, and cancellation requests. Such transactions are all an integral part of the MILSTRIP.

With the exception of certain classes of material, MILSTRIP is used for ordering material

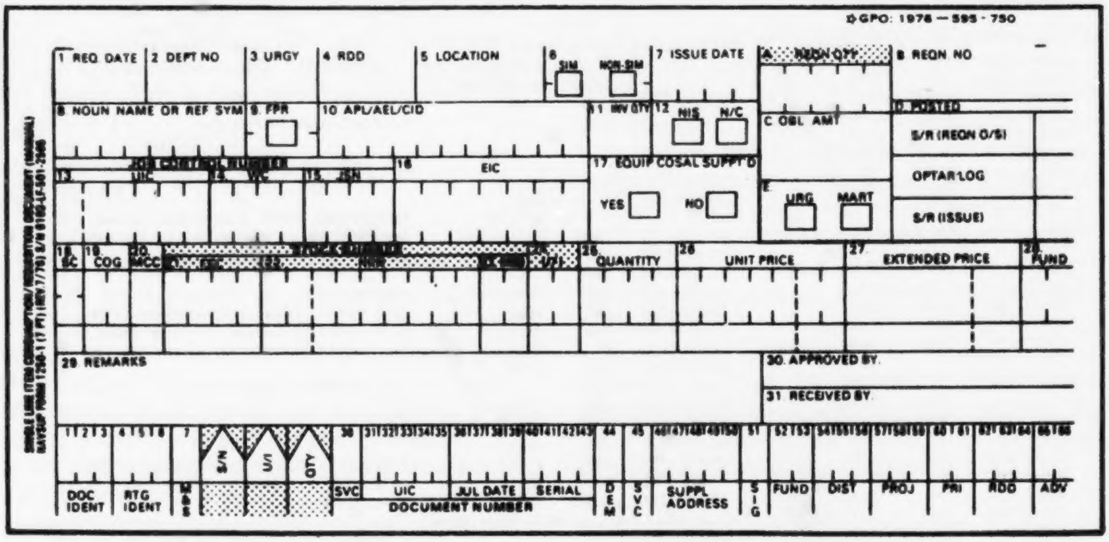

USE TYPEWRITER OR BALL POINT PEN
PRESS HARD
TO INSURE LEGIBILITY OF ALL COPIES
U. S. GOVERNMENT PRINTING OFFICE 1977 — 704 - 958

1 REQ DATE
2 DEPT NO
3 URGY
4 RDD
5 LOCATION
6 SIM ☐ NON-SIM ☐
7 ISSUE DATE
A REQN QTY
B REQN NO
8 NOUN NAME OR REF SYM
9 FPR ☐
10 APL AEL CID
11 INV QTY
12 NIS ☐ N/C ☐
C OBL AMT
D POSTED
S/R (REQN O/S)
OPTAR LOG
S/R (ISSUE)
JOB CONTROL NUMBER
13 UIC
14 WC
15 JSN
16 EIC
17 EQUIP COSAL SUPPT'D YES ☐ NO ☐
E URG ☐ MART ☐
PROJ __ __ __
18 SC
19 COG
20 MCC
STOCK NUMBER
21 FSC
22 NIIN
23 SMIC
24 U/I
25 QUANTITY
26 UNIT PRICE
27 EXTENDED PRICE
28 FUND
29 REMARKS
30 APPROVED BY
31 RECEIVED BY

SINGLE LINE ITEM CONSUMPTION DOCUMENT (MANUAL)
NAVSUP FORM 1250 (5 PT) (REV 7-78) S/N 0108-LF-501-2500

177.136

Figure 9-16.—Single Line Item Consuption Document (Manual), NAVSUP Form 1250.


GPO: 1978 — 595 - 750

1 REQ DATE
2 DEPT NO
3 URGY
4 RDD
5 LOCATION
6 SIM ☐ NON-SIM ☐
7 ISSUE DATE
A REQN QTY
B REQN NO
8 NOUN NAME OR REF SYM
9 FPR ☐
10 APL/AEL/CID
11 INV QTY
12 NIS ☐ N/C ☐
C OBL AMT
D POSTED
S/R (REQN O/S)
OPTAR LOG
S/R (ISSUE)
JOB CONTROL NUMBER
13 UIC
14 WC
15 JSN
16 EIC
17 EQUIP COSAL SUPPT'D YES ☐ NO ☐
E URG ☐ MART ☐
18 SC
19 COG
20 MCC
STOCK NUMBER
21 FSC
22 NIIN
23 SMIC
24 U/I
25 QUANTITY
26 UNIT PRICE
27 EXTENDED PRICE
28 FUND
29 REMARKS
30 APPROVED BY
31 RECEIVED BY

1 2 3	4 5 6	7				30	31 32 33 34 35	36 37 38 39	40 41 42 43	44	45	46 47 48 49 50	51	52 53	54 55 56	57 58 59	60 61	62 63 64	65 66
			S/N	U/I	QTY														
DOC IDENT	RTG IDENT	M & S				SVC	UIC	JUL DATE	SERIAL	DEM	SVC	SUPPL ADDRESS	SIG	FUND	DIST	PROJ	PRI	RDD	ADV
						DOCUMENT NUMBER													

SINGLE LINE ITEM CONSUMPTION/REQUISITION DOCUMENT (MANUAL)
NAVSUP FORM 1250-1 (7 PT) (REV 7/78) S/N 0108-LF-501-2600

177.137

Figure 9-17.—Single Line Item Consuption/Requisition Document (Manual), NAVSUP Form 1250-1.

through the Navy Supply System. These exemptions are listed in NAVSUP Pub 437, *Operating Procedures Manual for MILSTRIP/MILSTRAP.*

Requisition Documents

MILSTRIP requisitioning is based upon coded, single line item (one stock number) documents. Several types of documents are used to order material. The most commonly used documents are as follows:

1. NAVSUP Form 1250
2. NAVSUP Form 1250-1
3. DD Form 1348
4. DD Form 1348-6

Under certain circumstances, requisitions may be submitted either by message or by letter.

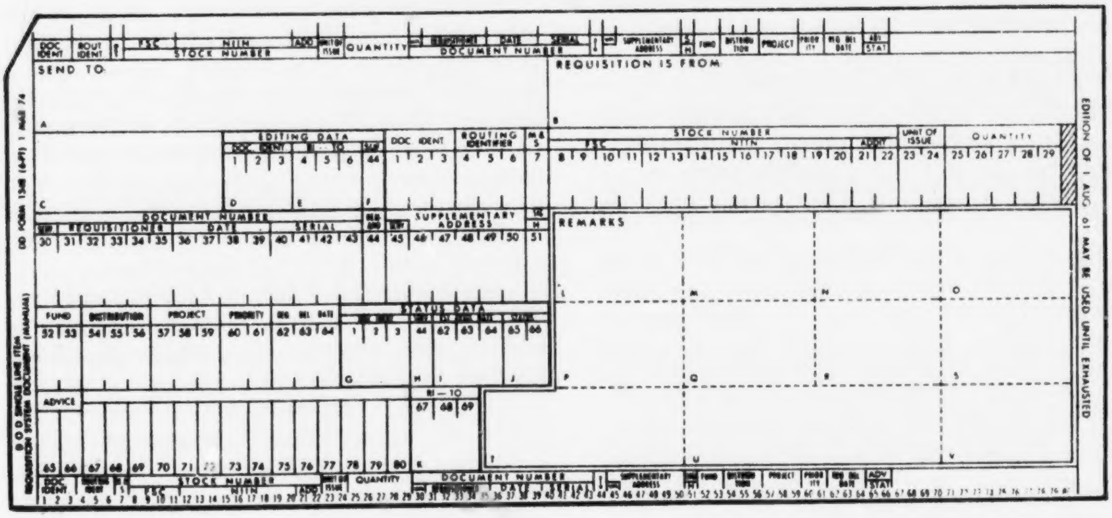
The following paragraphs describe the purpose and basic requirements for the forms just mentioned. Complete information concerning the preparation of these documents is contained in NAVSUP Pub 485, *Afloat Supply Procedures.*

In nonautomated ships, excluding submarine forces, issues of stock and direct turnover (DTO) material, as well as all chargeable services, are requested on the Single Line Item Consumption Document, NAVSUP Form 1250 (fig. 9-16). The DD Form 1348 is the consumption document that is used by automated ships other than those in the submarine forces.

The NAVSUP Form 1250-1 (fig. 9-17) is used as a consumption document by all submarine forces and as a MILSTRIP requisitioning document by nonautomated ships of the submarine forces. Primarily the form is used for procuring materials or services. Submarine tenders or bases also use the form as an invoice for materials supplied to supported units of the submarine forces. NAVSUP Forms 1250 and 1250-1 were developed to meet two needs: (1) to improve inventory control procedures and (2) to report consumption under the Maintenance Data System (MDS). The following general instructions must be followed in preparing the NAVSUP Form 1250 or 1250-1.

1. Use a ballpoint pen or typewriter.
2. Annotate each entry in the proper data block.
3. To avoid confusion between the numeric "0" and the alphabetic "O," use the communication 0 for zeroes.

The Single Line Item Requisition System Document (Manual), DD Form 1348 (fig. 9-18),


DOC IDENT
ROUT IDENT
FSC
NIIN
STOCK NUMBER
ADD
UNIT OF ISSUE
QUANTITY
DOCUMENT NUMBER
DATE
SERIAL
SUPPLEMENTARY ADDRESS
FUND
DISTRIBUTION
PROJECT
PRIORITY
REQ. DEL. DATE
ADV STAT
SEND TO
REQUISITION IS FROM
EDITING DATA
ROUTING IDENTIFIER
UNIT OF ISSUE
REQUISITIONER
REMARKS
STATUS DATA
ADVICE
RI — 10
DD FORM 1348 (6-PT) 1 MAR 74
DOD SINGLE LINE ITEM REQUISITION SYSTEM DOCUMENT (MANUAL)
EDITION OF 1 AUG 61 MAY BE USED UNTIL EXHAUSTED

177.138

Figure 9-18.—DD Form 1348.

is used to requisition material from naval supply activities. The form is also used to follow up, modify, cancel, or trace previously submitted requisitions. The form is available as two-part, four-part, or six-part carbon interleaved forms for manual use or as a single card form for mechanized use. All copies of the manual forms are identical except for data blocks T and U. The blocks are blank on the original, but the copies have a place printed on them to show the unit and total price. The mechanized form is basically the same as the manual, except that data blocks A and B are omitted.

Codes are used extensively in MILSTRIP requisitioning because only 80 alphabetic and/or numeric characters can be placed on the card. (This does not include the activity names shown in data blocks A and B.) Selecting the correct code to convey the proper information to the supplier is essential. The correct codes are just as important on a requisition as the correct NSN. A "ready reference" list of codes that apply to your ship would be a time-saver when selecting and interpreting such MILSTRIP codes as routing identifiers, project codes, advice codes, status codes, and fund codes. A reference list, published as NAVSUP Pub 409, is available through the supply system.

The DD Form 1348 is prepared by typewriter or ballpoint pen. Pencil is not to be used because pencil marks can cause errors when the requisition is processed through mark-sensing equipment at shore activities. In preparing requisitions, you do not have to space the entries within the "tic" marks printed on the forms, but you must make the entries within the proper data blocks. Remember to use the communication Ø on MILSTRIP requisitions when zeroes must be used.

Regardless of the form used, the NSN is the most important identification data for any item. Check the ML-N before listing the stock number on the 1250 or 1348 to ensure that the stock number is up-to-date and accurate and that the unit price and unit of issue are correct.

If the NSN is not available for repair parts, DD Form 1348-6 (fig. 9-19) is used to requisition the parts. DD Form 1348-6 consists of two sections: the first, or top, section consists of 80 card columns of MILSTRIP data; the second, or bottom, section consists of nine data blocks of additional identification data. The bottom section permits the inclusion of all available technical or descriptive data to be included. This data will assist the supply source in the identification and/or procurement of the requisitioned item.

Mandatory Turn-In Repairables

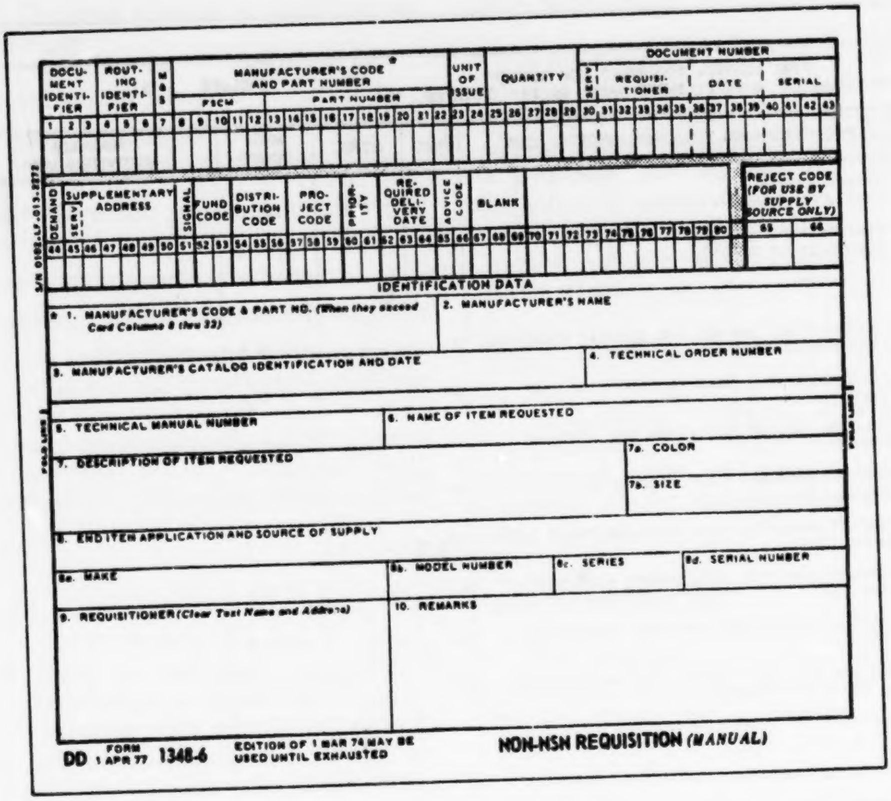
Since you will, no doubt, encounter the terms "mandatory turn-ins" and "repairables" in the process of obtaining replacement parts from supply, you should understand the purpose of the program and your responsibilities to it.

When any of your equipment fails, your primary concern is to locate the trouble, correct it, and get the equipment back on the line. In most instances this involves tracing the trouble to a defective part, obtaining the part from ready spares, and installing it. You must then prepare a NAVSUP 1250 (or DD 1348) and obtain a replacement from the supply department. When the defective part is expensive and repairable (as with most FCS modules), we encounter the repairables program.

A large number of parts can be economically repaired when they fail. This results in savings of dollars and time since it is quicker and cheaper to repair an item than to contract for and buy a new one—provided that the old item is promptly returned in repairable condition.

For the program to work as intended, you and others have certain responsibilities. At the time your request for a mandatory turn-in item is presented, supply must inform you that the defective item is to be returned. Your responsibilities begin at this point. You must remove the defective part without further damaging it. You must then provide adequate protection to the part so that it will not be further damaged before it is turned in to supply. The most effective way is to place the defective part in the same container in which you received the replacement part. Do not cannibalize components which you might possibly use sometime in the future.

When the required part is not in the storeroom, supply must then take appropriate action to obtain it. The failed part must still be returned and should be turned in prior to receiving the replacement part. This way, the failed part can enter the repair cycle and be available for reissue that much sooner. The only



DOCUMENT IDENTIFIER	ROUTING IDENTIFIER	M & S	MANUFACTURER'S CODE AND PART NUMBER *		UNIT OF ISSUE	QUANTITY	DOCUMENT NUMBER			
			FSCM	PART NUMBER			SERV	REQUISITIONER	DATE	SERIAL
1 2 3	4 5 6	7	8 9 10 11 12	13 14 15 16 17 18 19 20 21 22	23 24	25 26 27 28 29	30	31 32 33 34 35	36 37 38 39	40 41 42 43

DEMAND	SUPPLEMENTARY ADDRESS		SIGNAL	FUND CODE	DISTRIBUTION CODE	PROJECT CODE	PRIORITY	REQUIRED DELIVERY DATE	ADVICE CODE	BLANK		REJECT CODE (FOR USE BY SUPPLY SOURCE ONLY)
	SERV											
44	45	46 47 48 49 50	51	52 53	54 55 56	57 58 59	60 61	62 63 64	65 66	67 68 69	70 71 72 73 74 75 76 77 78 79 80	65 66

S/N 0102-LF-013-2272

IDENTIFICATION DATA

* 1. MANUFACTURER'S CODE & PART NO. *(When they exceed Card Columns 8 thru 22)*

2. MANUFACTURER'S NAME

3. MANUFACTURER'S CATALOG IDENTIFICATION AND DATE

4. TECHNICAL ORDER NUMBER

FOLD LINE

5. TECHNICAL MANUAL NUMBER

6. NAME OF ITEM REQUESTED

7. DESCRIPTION OF ITEM REQUESTED

7a. COLOR

7b. SIZE

8. END ITEM APPLICATION AND SOURCE OF SUPPLY

8a. MAKE

8b. MODEL NUMBER

8c. SERIES

8d. SERIAL NUMBER

9. REQUISITIONER *(Clear Text Name and Address)*

10. REMARKS

DD FORM 1 APR 77 1348-6 EDITION OF 1 MAR 74 MAY BE USED UNTIL EXHAUSTED

NON-NSN REQUISITION *(MANUAL)*

43.24.6

Figure 9-19.—DD Form 1348-6.

exception should be when the failed part will permit limited or reduced operation of equipment until the replacement is received.

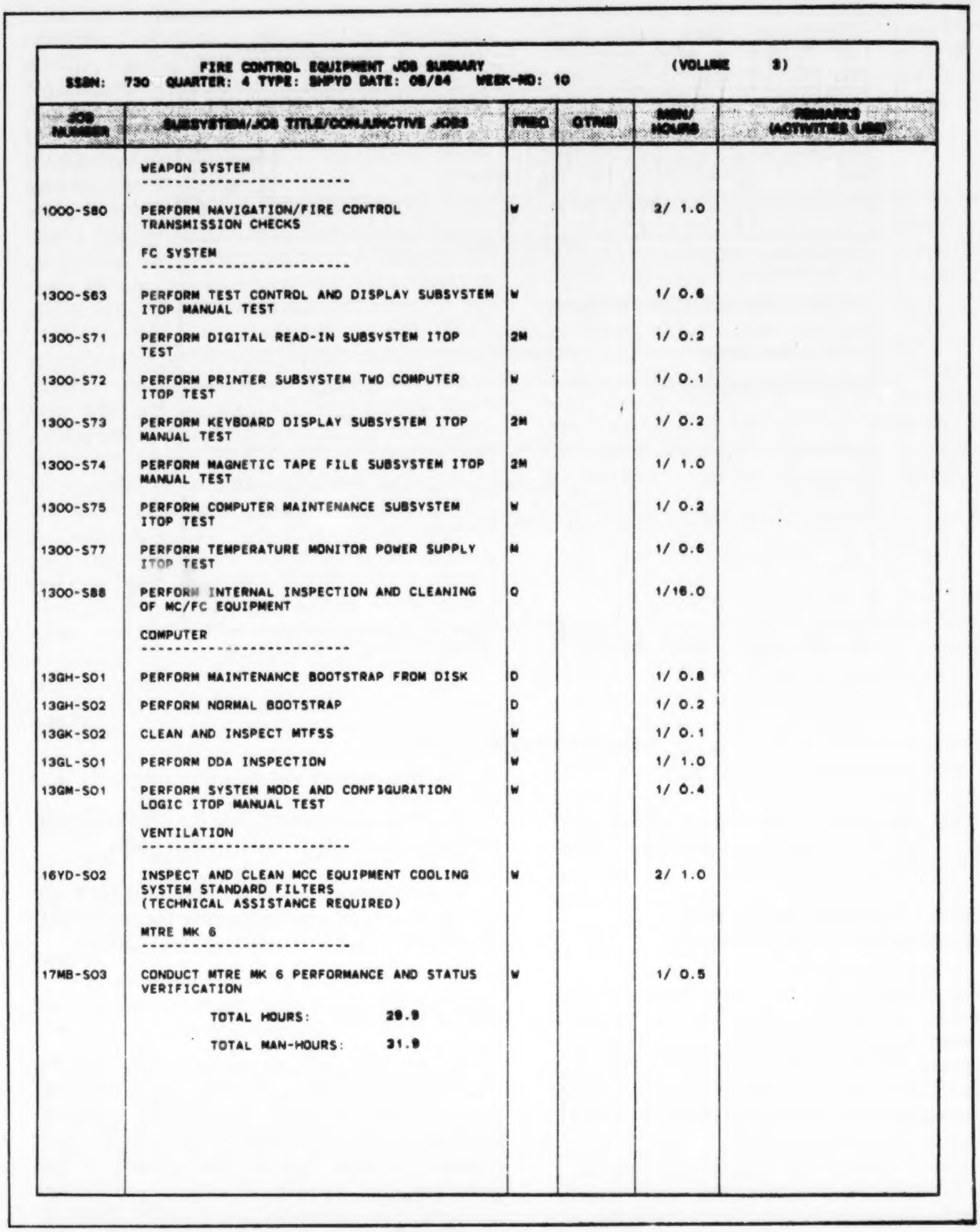
PREVENTIVE MAINTENANCE MANAGEMENT PLAN (PMMP)

The PMMP provides recommended job schedules, based on preventive maintenance minimum requirements for equipment under the cognizance of the Strategic Systems Program Office (SSPO), and for certain weapon support systems equipment. The objectives of the PMMP are to:

1. Identify the preventive maintenance tasks required, with reference to proper procedures in the technical publications
2. Provide a standard plan for scheduling and managing preventive maintenance tasks
3. Establish a method for obtaining feedback information to be used to improve the equipment, the PMMP, and the technical publications

ORGANIZATION

The PMMP provides master volumes for the weapons officer and navigation officer (volumes 1 and 2) and individual volumes for particular equipment groups (volumes 3 through 7). Each volume contains PMMP instructions, a job summary, an equipment index, job tickets arranged in job schedules, and PMMP Planning/Checkoff Sheets. Volumes 1 and 2 also contain



FIRE CONTROL EQUIPMENT JOB SUMMARY (VOLUME 3)
SSBN: 730 QUARTER: 4 TYPE: SHPYD DATE: 08/84 WEEK-NO: 10

JOB NUMBER	SUBSYSTEM/JOB TITLE/CONJUNCTIVE JOBS	FREQ	QTR(S)	MEN/ HOURS	REMARKS (ACTIVITIES USE)
	WEAPON SYSTEM ------------------------				
1000-S80	PERFORM NAVIGATION/FIRE CONTROL TRANSMISSION CHECKS	W		2/ 1.0	
	FC SYSTEM ------------------------				
1300-S63	PERFORM TEST CONTROL AND DISPLAY SUBSYSTEM ITOP MANUAL TEST	W		1/ 0.6	
1300-S71	PERFORM DIGITAL READ-IN SUBSYSTEM ITOP TEST	2M		1/ 0.2	
1300-S72	PERFORM PRINTER SUBSYSTEM TWO COMPUTER ITOP TEST	W		1/ 0.1	
1300-S73	PERFORM KEYBOARD DISPLAY SUBSYSTEM ITOP MANUAL TEST	2M		1/ 0.2	
1300-S74	PERFORM MAGNETIC TAPE FILE SUBSYSTEM ITOP MANUAL TEST	2M		1/ 1.0	
1300-S75	PERFORM COMPUTER MAINTENANCE SUBSYSTEM ITOP TEST	W		1/ 0.2	
1300-S77	PERFORM TEMPERATURE MONITOR POWER SUPPLY ITOP TEST	M		1/ 0.6	
1300-S88	PERFORM INTERNAL INSPECTION AND CLEANING OF MC/FC EQUIPMENT	Q		1/16.0	
	COMPUTER ------------------------				
13GH-S01	PERFORM MAINTENANCE BOOTSTRAP FROM DISK	D		1/ 0.8	
13GH-S02	PERFORM NORMAL BOOTSTRAP	D		1/ 0.2	
13GK-S02	CLEAN AND INSPECT MTFSS	W		1/ 0.1	
13GL-S01	PERFORM DDA INSPECTION	W		1/ 1.0	
13GM-S01	PERFORM SYSTEM MODE AND CONFIGURATION LOGIC ITOP MANUAL TEST	W		1/ 0.4	
	VENTILATION ------------------------				
16YD-S02	INSPECT AND CLEAN MCC EQUIPMENT COOLING SYSTEM STANDARD FILTERS (TECHNICAL ASSISTANCE REQUIRED)	W		2/ 1.0	
	MTRE MK 6 ------------------------				
17MB-S03	CONDUCT MTRE MK 6 PERFORMANCE AND STATUS VERIFICATION	W		1/ 0.5	
	TOTAL HOURS: 29.9				
	TOTAL MAN-HOURS: 31.9				

Figure 9-20.—PMMP Job Summary. 177.139

a job index. The seven volumes of the PMMP are divided as follows:

1. Weapon system schedule
2. Navigation system schedule
3. Fire control equipment quarterly schedule
4. Missile/launcher equipment quarterly schedule
5. Sonar section quarterly schedule
6. Navigation equipment quarterly schedule
7. Weapon support systems pressure instrumentation in-place qualification schedules

Volumes 1 and 2 are distributed with each general revision of the PMMP system. Volumes 3 through 7 are distributed about five weeks before they will be used.

JOB INDEX

A job index is contained in volumes 1 and 2. The index provides the weapons officer or navigator with an overall view of equipment job requirements and scheduling. The job index refers to the volume containing the job ticket for each job. The frequency of each job is indicated in the appropriate column. The frequency symbols and their meanings are as follows:

1P	Once during the period indicated
2P	Twice during the period indicated
D	Daily
2W	Twice per week
W	Weekly
2M	Twice per month
M	Monthly
2Q	Twice per quarter
Q	Quarterly
SA	Semiannually
AN	Annually

The above symbols are also used in the job summaries and may appear on job tickets.

JOB SUMMARY

A job summary (fig. 9-20) is included in the front of volumes 3 through 7. The summary is a management tool for the leading petty officer (LPO). Using the summary, the LPO can locate a particular job number and determine the frequency of performance, the number of men required, and how many hours the job is expected to take. The job summary also provides weekly totals of hours and man-hours.

EQUIPMENT INDEX

An equipment index (fig. 9-21) is included in all volumes of the PMMP. The index provides equipment codes for specific equipment and indicates which volume contains the PMMP for that equipment.

JOB SCHEDULES

Job schedules are arrangements of PM job tickets that have been assigned on a weekly basis or are listed for accomplishment during a designated period or special event.

For planning purposes, the operational cycle or maintenance quarter is normally organized into four periods:

1. Availability period—weeks one through three
2. Predeployment period—week four (last week of tender availability)
3. Patrol period—weeks five through fourteen
4. Preavailability period—week 15 (or last week of patrol cycle)

Weekly job schedules contain recommended PM jobs for accomplishment during the 15 weeks of the SSBN normal operational cycle. The patrol period may contain either more or less than 10 weeks of job tickets, depending on the expected length of the patrol. In all cases, the jobs contained in the preavailability period schedule should be performed during the week prior to entering port.

Special event job schedules provide for nonregularly scheduled situations or conditions that permit or require accomplishment of PM tasks. Abbreviations and associated terms for the

WEAPON SYSTEM EQUIPMENT INDEX

EQUIP CODE	EQUIPMENT NOMENCLATURE	VOLUMES
93L0	TEST CONTROL DISPLAY SUBSYSTEM	3
93PA	PRINTER SUBSYSTEM	3
93RT	RELAY ACTUATOR TESTER (2213115G5)	3
93SE	GUIDANCE TEMPERATURE MONITOR MK 27 MOD 1	3
93SJ	CARRIER HOIST ASSEMBLY (2673069G1)	4
93SL	ELECTRONICS ASSEMBLY HANDLING FIXTURE (3241122-3)	4
93SM	IMU LIFTING DEVICE (3203689G1)	4
93ST	MK 5 ELECTRONICS ASSEMBLY TEST STAND AND TEST STAND ADAPTER	4
93SU	INERTIAL MEASUREMENT UNIT TEST STAND (3250716G1)	3
9400	NAVIGATION SYSTEM	6
94A0	SINS MK 2 MOD 3, 6	6
94AA	STABLE PLATFORM	6
94AB	SINS NAVIGATION CONSOLE	6
94AJ	TAPE READER	6
94AL	TYPEWRITER AND CONTROL UNIT	6
94AM	GYRO MONITOR CONTROL CONSOLE	6
94AT	MARDAN COMPUTER	6
94AU	MARDAN HANDLING EQUIPMENT	6
94B0	NAVIGATION COMPUTER	6

177.140

Figure 9-21.—Equipment Index.

special events associated with the PMMP are as follows:

CY	Cyclic
DT	Dock Trials
DD	Dry Dock
DL	Pre-DASO Loadout
ES	Equipment Shutdown
FP	First half of DASO preparations
IL	Pre-initial Loadout
ML	Missile Loading
PL	Post Launch .
SP	Second half of DASO preparations
TA	Technical Assistance

PM job tickets are prepared in the format shown in figure 9-22. The job ticket consists of a removable ticket issued to the technician by the LPO and a record stub retained by the LPO. Job tickets are designed to accomplish the following:

1. Identify specific PM tasks, and provide references to Standard Maintenance Procedures (SMPs) or to detailed procedures in other technical publications
2. Serve as a means of scheduling PM tasks within the operational cycles
3. Provide for management control of job assignment and performance and serve as a record of job completion or noncompletion at the LPO level
4. Provide a rapid, simple method for submitting recommended improvement comments to correct or update the PMMP

Entries on job tickets consist primarily of job number, job sequence number, job frequency, hull number, equipment, job title, and reference publication. Figure 9-23 illustrates the number codes for the job number on the ticket. A job number is assigned to each required PM task. The job number is a seven-character code that identifies the applicable SSBN class, the cognizant SSPO or NAVSEA code, equipment code, and a specific job number associated with that equipment.

The job sequence number appears immediately below the job number on the ticket and serves as a locator in the PMMP for identifying a removed ticket with its stub. A typical job sequence number is shown in figure 9-24.

Each job ticket includes standard nomenclature of the specific system or equipment, a job title, and reference to another technical publication containing the required procedures.

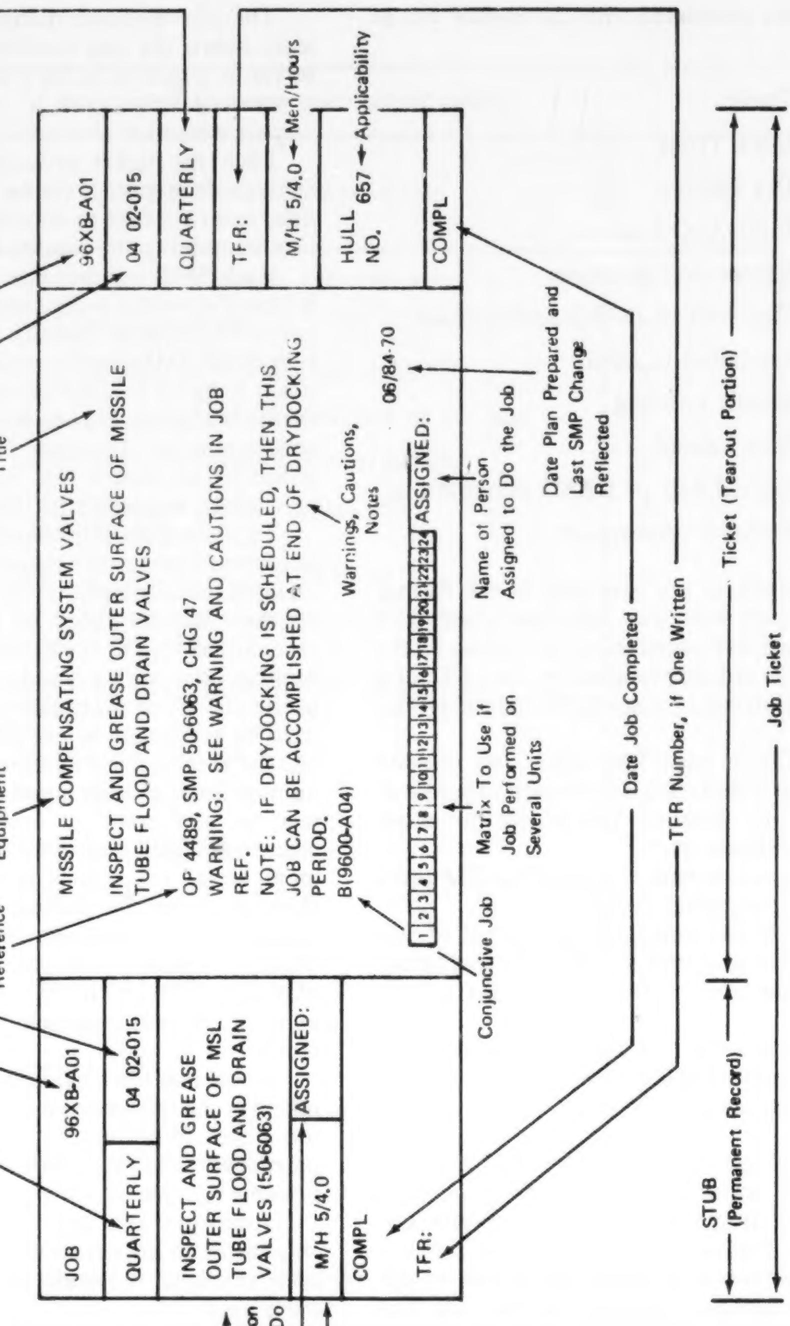
Each SMP number that is on the job ticket is identified with a 6-digit number. The two digits before the hyphen identify the volume and the part of the SMPs that contain the procedure (the ticket in figure 9-22 refers you to volume 5). The numbers after the hyphen refer to the specific procedure number. The latest change to the SMP is indicated to ensure that you follow the most up-to-date procedure for the job.

To assist with shipboard scheduling, the job numbers of preventive maintenance tasks recommended for accomplishment in conjunction with another job are listed in parentheses on the tear-out portion of the ticket. A conjunctive job number listed with a mandatory scheduling code prefix (B, W, or A) indicates that the job ticket must be performed before (B), with (W), or after (A) the specified job number. A conjunctive job number listed without a prefix indicates a job that can be performed to increase efficiency by reducing elapsed time, total man-hours, or equipment wear. Job tickets in a given weekly job schedule normally include only those related conjunctive job numbers appearing in the same weekly schedule. Semiannual and annual tasks may be conjunct with PM jobs that are scheduled at more frequent periods, such as weekly or monthly PM jobs.

A note that warnings and/or cautions are contained in the referenced procedure appears on the job ticket. Warnings call attention to possible personnel hazards, while cautions refer to possible equipment damage.

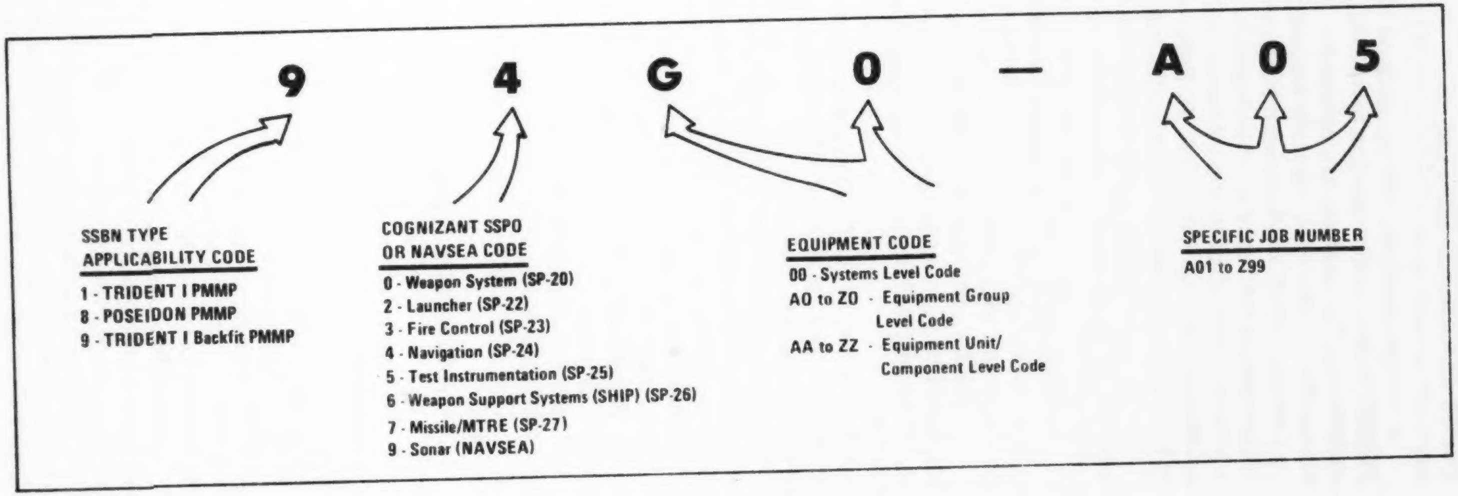
Notes may also appear on the job ticket to emphasize an important procedure or condition such as a need to obtain special test equipment from TRF.

Each job ticket includes estimates of the minimum number of people and the time it will take those people to perform the assigned tasks. The time estimate in hours is based on the number of equipment units on which the PM is to be


Abbreviated Title
Name of Person Assigned To Do the Job
Men/Hours
JOB
96XB-A01
QUARTERLY
04 02-015
INSPECT AND GREASE OUTER SURFACE OF MSL TUBE FLOOD AND DRAIN VALVES (50-6063)
M/H 5/4.0
ASSIGNED:
COMPL
TFR:
Job Frequency
Job Number
Job Sequence Number
Reference
Equipment
Title
MISSILE COMPENSATING SYSTEM VALVES
INSPECT AND GREASE OUTER SURFACE OF MISSILE TUBE FLOOD AND DRAIN VALVES
OP 4489, SMP 50-6063, CHG 47
WARNING: SEE WARNING AND CAUTIONS IN JOB REF.
NOTE: IF DRYDOCKING IS SCHEDULED, THEN THIS JOB CAN BE ACCOMPLISHED AT END OF DRYDOCKING PERIOD.
B(9600-A04)
Warnings, Cautions, Notes
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ASSIGNED:
06/84-70
96XB-A01
04 02-015
QUARTERLY
TFR:
M/H 5/4.0
Men/Hours
HULL NO. 657
Applicability
COMPL
Conjunctive Job
Matrix To Use if Job Performed on Several Units
Name of Person Assigned to Do the Job
Date Plan Prepared and Last SMP Change Reflected
Date Job Completed
TFR Number, if One Written
STUB (Permanent Record)
Ticket (Tearout Portion)
Job Ticket

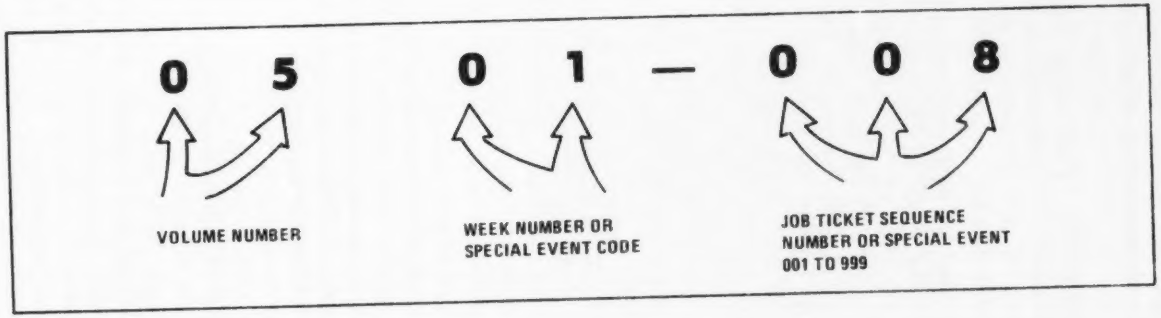
177.141

Figure 9-22.—PMMP Job Ticket.


9
4
G
0
—
A
0
5
SSBN TYPE
APPLICABILITY CODE
1 - TRIDENT I PMMP
8 - POSEIDON PMMP
9 - TRIDENT I Backfit PMMP
COGNIZANT SSPO
OR NAVSEA CODE
0 - Weapon System (SP-20)
2 - Launcher (SP-22)
3 - Fire Control (SP-23)
4 - Navigation (SP-24)
5 - Test Instrumentation (SP-25)
6 - Weapon Support Systems (SHIP) (SP-26)
7 - Missile/MTRE (SP-27)
9 - Sonar (NAVSEA)
EQUIPMENT CODE
00 - Systems Level Code
AO to ZO - Equipment Group Level Code
AA to ZZ - Equipment Unit/ Component Level Code
SPECIFIC JOB NUMBER
A01 to Z99

177.142

Figure 9-23.—PMMP job number.


0
5
0
1
—
0
0
8
VOLUME NUMBER
WEEK NUMBER OR
SPECIAL EVENT CODE
JOB TICKET SEQUENCE
NUMBER OR SPECIAL EVENT
001 TO 999

177.143

Figure 9-24.—PMMP job sequence number.

performed. Unless otherwise specified, the PM is to be performed on all units aboard. The time estimate includes equipment setup, closure, and return to normal tactical readiness. It does not include the time used for any required troubleshooting, corrective maintenance, or testing of equipment upon completion of corrective maintenance.

A job assigned to a particular operational period is indicated in the appropriate blocks by the frequency of performance or event code associated with that job.

A job assigned to a particular week is indicated in the appropriate block by the week number(s). Since the periods of predeployment and preavailability are only one week in length, their week number is not indicated. These jobs automatically appear in weeks 4 and 15. Following week one, tickets for the availability period are job tickets that are to be performed once during the three week availability period. These tasks should be scheduled during the availability period as desired by the division officer of LPO.

All PMMPs must be logged in the weapons or navigation work log. PMMPs are logged by job number with the results. For unsatisfactory results, you must include a description of the results, circumstances, and any unsatisfactory retests.

If a job cannot be completed as scheduled, it should be rescheduled to the earliest possible week of the quarter or passed to the relieving crew. SSBN rescheduling of PMMP jobs is appropriate to compensate for on-site conditions.

PMMP PLANNING/CHECKOFF SHEETS

PMMP Planning/Checkoff Sheets are management tools used by division officers and LPOs to plan and maintain the status of overall PMMP job accomplishment. The sheets are organized by major equipment groups and provide a summary of all PMMP jobs scheduled during each week for each group. Jobs requiring special coordination efforts are identified by symbols. The symbols are explained on each diagram.

PMMP FEEDBACK SYSTEM

A simple feedback system is used in the PMMP system to encourage you to submit recommendations for system improvement. While doing PM jobs, you should evaluate the requirements. Write any comments or recommendations on the back of the job ticket and return it to your LPO. At the end of the patrol, the tickets will be sent to SSPO. Each PMMP volume includes a preaddressed envelope for this purpose.

Examples of PMMP problems requiring feedback comments are:

1. Problems in completing job requirements, such as not having test equipment aboard or the job interfered with shipboard procedures
2. PMMP job tickets, indexes, or test specifications were inadequate or incorrect
3. Incorrect SMP or reference publication number
4. Referenced publication not on board
5. Job not scheduled often enough or assigned too often
6. Job can be done more efficiently or conveniently during another period or week of the operational cycle
7. Need for a new PM job, deletion of a job, or combining one job with another
8. Job inapplicable to the system or equipment on the ship
9. Number of personnel and hours estimated for the job performance are not accurate
10. Conjunctive jobs listed on a ticket require a change
11. Suggestions concerning PMMP improvements
12. Problems concerning warnings or cautions on job tickets

When you write comments for feedback, provide enough information for the contractor personnel to evaluate the recommendation. In many cases, insufficient information makes it impossible to take proper action on a comment.

Fleet feedback comments are the primary input to the PMMP feedback information system. These, together with appropriate comments from TFRs, patrol reports, and SSBN crew debriefings, are evaluated for program improvement. It should be readily apparent, therefore, that feedback in the PMMP is extremely important to keep the system working at its fullest capacity.

A PMMP feedback bulletin of all current comments is distributed quarterly. Action status for each comment is indicated by contractor reply or SSPO decision. PMMPs are updated continuously to include approved fleet recommendations and new data from subsystems contractors.

Further information on the PMMP is available in the individual volumes distributed to your command.

The application of PMMP may vary at shore installations, but the importance of the program should be stressed at every command.

EQUIPMENT ALTERATIONS

In carrying out your duties, you will occasionally come into contact with various equipment alteration plans. Generally, your duties concerning these modifications will consist of either carrying out the alteration yourself, assisting support technicians in making the alterations, or simply monitoring the progress of the alteration. These alterations are usually necessary to improve the efficiency of the equipment or eliminate equipment hazards. There are three types of alterations that you may come in contact with as a Fire Control Technician. These are the Strategic Systems Project Alteration (SPALT), Ordnance Alteration (ORDALT), and the Ship Alteration (SHIPALT).

STRATEGIC SYSTEMS PROJECT ALTERATIONS (SPALTs)

Most alterations with which you will be concerned are those under the cognizance of SSPO. Whenever a significant change is to be made to an SWS weapon or subsystem component, it is usually authorized and carried out by the SPALT program. The documents used in implementing the program are called SPALTs. A SPALT document includes information concerning the applicability of the alteration, plans, drawings, priority, name of the repair activity authorized to accomplish the alteration, procedures to be followed when performing the alteration, and checkout procedures to be followed when the alteration has been accomplished.

While it is recognized that a great number of marginal improvements can be made in a weapon system, SPALTs are normally issued only when a real need can be demonstrated for the alteration and when, considering the cost, manpower, and system effectiveness, a positive advantage to the system will occur.

The SPALT program consists of three phases: proposals, preparation, and accomplishment.

SPALT Proposals

SPALT proposals may be originated and submitted by an activity, naval or contractor, involved in the design production, maintenance or operation of SWS weapon system equipment or ships. However, most proposals are originated by SWS contractors who have responsibility for the design of SWS equipment.

The purpose of the proposal is to provide SSPO with sufficient information to make a comprehensive evaluation of the need for the recommended alteration; to weigh benefits it will provide versus its estimated cost in terms of money, manpower, and materials; and to assess its probable impact on the SWS.

SPALT Preparation

SPALT preparation begins when the SPALT preparing activity receives the approved SPALT proposal and the SPALT preparation instructions. Preparation is not limited to the technical design of an alteration; it encompasses all those functions required to formulate a "complete package" for the implementation of the SPALT. Although the preparing activity is responsible for designing the alteration and ensuring that the alteration fulfills its intended purpose, SPALT preparation is a team effort requiring cooperation, coordination, and communication among all activities involved with careful attention given to the approved preparation schedule.

SPALT Accomplishment

When SPALTs have been authorized by SSPO, they must be accomplished expeditiously so that the benefits may be realized as soon as possible, deficiencies may be corrected in a timely manner, and logistics simplified by reducing the number of different configurations to be supported. To ensure achievement of this objective, SWS contractors and activities report the status of SPALT preparation, SPALT kit delivery, repair part delivery, publication delivery, and conjunctive alterations. This information is recorded in the SPALT data files maintained by SSP SPALT control and serves as the basis for preparation of documents that provide SPALT accomplishment and support information.

When a SPALT is accomplished on equipment in service, a decal carrying the SPALT identification number is affixed to the altered equipment and the same identifying number is stamped on the SPALT accomplishment plate furnished on the configuration item. A SPALT accomplishment form must be filled out and forwarded according to SPPINST 4720.11.

Because the accomplishment of SPALTs in the field is dependent upon the availability of the equipment for alteration, any given SPALT cannot be accomplished on all similar equipment in service at the same time. SSPO issues a report on the status of SPALTs. This report is designated as SSP report 4720.1.

NAVSEA OPs published under the direction of SSPO will generally contain a page in the front listing the SPALTs affecting the equipment by number, with a brief description of the specific SPALT.

ORDNANCE ALTERATIONS (ORDALTS)

Another alteration that you will become familiar with because of your involvement with ordnance materials is the ORDALT. These alterations to ordnance equipment are approved by Navy Sea Systems Command (NAVSEASYSCOM). An ORDALT instruction furnishes the necessary information to accomplish the ORDALT, while an ORDALT kit provides the material needed in much the same way as the SPALT program. The number of the completed ORDALT is stamped on a metal plate on the equipment and recorded in the maintenance history of the equipment.

ORDALT 00 provides a numerical index of issued ORDALTs and the equipment affected.

SHIP ALTERATIONS (SHIPALTS)

The only other alterations that you may work with are issued by NAVSEASYSCOM and are labeled SHIPALTs. SHIPALTs are issued in the same manner as SPALTs and ORDALTs except that the alteration affects ship equipment.

CALIBRATION RECALL PROGRAM

In the performance of your maintenance duties as a Fire Control Technician, you will be working with various precision instruments, such as torque wrenches, multimeters, oscilloscopes, and so on. It is important that this equipment be maintained in an accurate (calibrated) condition for extended periods of use.

The Navy has established a program for the periodic calibration of standards and test and measurement equipment. The purpose of this program is to ensure optimum performance of all Navy ships' weapon systems test equipment. For this reason, calibration of test and measurement equipment and laboratory standards is mandatory.

To this end, the Navy has established a calibration laboratory at the TRIDENT Refit Facility (TRF) and SSBNs are considered to be field calibration activities. In conjunction with the general Navy program, SSPO has established the SWS calibration program to support the test and measuring equipment of the SWS submarines and TRF. SSPO initiates calibration recall schedules to the TRF monthly and to SSBNs quarterly, listing their equipment and the calibration required.

The TRF coordinates with each SSBN to accomplish calibration work required using advance copies of the recall schedule. They also submit reports to squadron concerning the status of SSBN equipment calibrated by the laboratory.

The SSBN is responsible for delivering equipment for calibration and picking it up when it is done. They must establish priorities for calibration of their equipment and schedule with the TRF any calibration that must take place on board the ship.

Keep in mind that SSBNs are field calibration activities and calibrate much of their own equipment using a torque tester and gage calibration kit maintained and operated primarily by Missile Technicians.

As a member of the crew, you should ensure that your recall list is maintained in a correct condition, notifying your coordinator of any needed changes. You should always ensure that equipment you are using to perform your duties is calibrated and, if not, deliver it to TRF for calibration.

The equipment required to carry out planned evolutions should not be delivered to the laboratory if the evolutions are to be accomplished prior to the equipment being returned unless the previous calibration sticker has expired. An important factor to keep in mind is that enough equipment must always be withheld to maintain the work schedule.

WEAPONS SYSTEM LOGS

In addition to the traditional and obvious functions of a work log at a watch station, conscientiously maintained work logs provide a valuable source of continuity between watchstanders and between alternate crews. Completion of all required elements of an extended evolution that brackets the crew change, such as a missile transfer, can be readily verified by reference to work logs.

These logs are the most important data originated during an upkeep and patrol. The logs reflect valuable crew interpretation and opinion of system performance during the upkeep and patrol. The compiled data is extremely useful in determining which path to follow in isolating consistent equipment failures or detecting unsatisfactory trends in equipment reliability and performance. This data provides a means for contractor analysts to discover undetected problems or resolve intermittent problems, which may seriously degrade tactical readiness. SSBN data also provides a source for identification of error, ambiguities, and inadequacies in operating procedures and other documentation.

LOG FORMS

As a Fire Control Technician, you will be associated with five basic log forms. These forms are used to make up the Fire Control Supervisor's Log, the Launcher Supervisor's Log, and the Intermittent Failure log. These forms are as follows:

1. The MCC Log form was designed to contain most of the Service Log related information.
2. The MCC Continuation/Subsystem Log form is used as a continuation sheet for Fire Control and is the basic logkeeping form for the Missile Compartment and Ship's Depth Control Systems Log.
3. The Pre/Post Patrol Guidance Configuration Summary form is used to record Guidance System serial number information and, when completed, comprises part of the Missile Compartment Log.
4. The Pre-Patrol Missile Configuration Summary is used to record other missile component serial numbers and is inserted, when completed, as part of the Missile Compartment Log.
5. The Intermittent Failure Log form is used as an aid in the fault isolation of intermittent missile-related failures. It is specifically designed to aid the technician in the trend detection required. It should be transcribed upon direction of applicable fault isolation procedures. As forms are used, they are to be submitted as part of the MCC Log.

GENERAL FBM LOG REQUIREMENTS

The following general procedures and comments apply to the completion of all FBM logs and data forms:

1. All log pages and data forms will be dated with current day, month, and year.
2. All time entries will be in Greenwich Mean Time (Zulu).
3. Any evolution involving testing, maintenance, or repair of weapons system equipment must be logged in the appropriate log.
4. Coordination among logkeeping locations is required. Logkeepers should know who is to record what information.
5. Logs should be treated as an informal, chronological, realtime record of events as they occur rather than a formal after-the-fact summary.

6. Periodic summaries in the logs that list the current status of unresolved or intermittent problems are useful not only to contractor analysts but also to various watchstanders and the alternate crew. These summaries should be prepared by the weapons officer twice a week during upkeep and weekly during patrol. Summaries should be submitted to the commanding officer for his acknowledgement. It should be noted that a summary of problems is a supplement to and not a substitute for a detailed description of the problem at the time it occurs.

7. Use of common abbreviations and acronyms is acceptable. However, use of nonstandard, ambiguous terminology is discouraged.

8. Carbon copies of all logs will be retained by the SSBN in accordance with TYCOM directives. Log originals will be forwarded in the upkeep or patrol weapons system data package. The IFL is an exception. For subsequent analysis, it is important that all entries be made with sufficient ballpoint pen pressure to produce legible copies.

9. Classify log page as applicable by blacking out one of two prepared classification stamps. Overclassification of the log will result if the SECRET stamp is not crossed out when CONFIDENTIAL is applicable.

10. Record all troubles that did not cause downtime or for which no repair was attempted but which may require eventual corrective action; for example, gas or hydraulic leaks.

11. Record any anomalous conditions discovered or observed that would affect system reliability or readiness. Include effects of ship's motion on system performance.

12. Record the following times in the log:

- Time malfunction was first detected
- Time cause of malfunction was finally isolated
- Time repair or replacement was completed
- Time verification of repair or replacement was completed by inspection or test

13. If unsatisfactory conditions are observed, record the PMMP or SMP number, time of failure, and, as applicable, tube(s) or equipment, on which performed; indication of failure; cause of failure, if determined; corrective action taken or reason for not taking action; repairs made; any out-of-specification conditions remaining; satisfactory retests; dispositon of failed components; and trouble and failure report (TFR) number.

The detailed requirements for completing each of the logs can be found in the SSBN Officer's Guide for POSEIDON Weapon System OD 43482.

SUMMARY

This chapter has covered a variety of administrative programs. Each program and topic in this chapter is important to you as an FTB. You are (or soon will be) responsible for maintaining or operating within each of the covered programs. Every FTB is required to be knowledgeable in logkeeping procedures, the 3-M program, and the PMMP program. From time to time you may be assigned as your division's publication, supply, or SPALT petty officer. Hopefully, you will be able to use the knowledge you acquired here (along with the publications available to you) to do a 4.0 job in that assignment.

APPENDIX I

GLOSSARY

Term or Abbreviation	Stands For
A	Accumulator register
AC	Attack center
access time	The time from request to delivery of data from storage
ACIP	Attack Center Indicator Panel
A/D	Analog/digital
ADC	Analog-to-digital converter
AFRSS	Automatic fault registration subsystem
AII	Automatic input interrupt
A/I	Actuator/indicator
ALNSS	Alignment subsystem
APC	Accelerometer pulse converter
APD	Accelerometer pulse decoder
APM	Accelerometer pulse line monitor
BAREL	Base calculation results
BASC	Base calculations; a program that performs the mathematical processing to compute ranges and bearings of targets from base points

Term or Abbreviation	Stands For
Baim	Launch bearing correction in the horizontal plane due to azimuth misalignment between missile outer gimbal axis and SINS outer gimbal axis
BCP	Ballast Control Panel
Bdaim	Launch bearing correction in the deck plane due to azimuth misalignment between missile outer gimbal axis and SINS outer gimbal axis
Bmr	Relative missile bearing (the clockwise angular displacement between the missile azimuth reference axis and the horizontal reference axis measured in a horizontal plane)
bootstrap	A manually activated, wired-in program of DCC instructions which prepares a DCC to accept information from perforated tape of magnetic disk file (MDF)
By	True target bearing
Byrg	Computed true bearing of the horizontal reference axis at launch

Term or Abbreviation	Stands For
CA	Coarse alignment
CALUP	Calibration and update program; a program that recalibrates the GUPELs and updates the GUPEL test parameter values in the MDF
CB	Circuit breaker
CBS	Course bearing servo
CDA	Channelized DRISS assembly
CDSS	Control and display subsystem
CE	Course erection
CO	Cutoff (command signal to the missile propulsion system initiating termination of thrust)
control word	A 24-bit word used to control buffer operations into and out of core memory
Cqhm	Inner gimbal angle. Equal to -Bmr when stable platform is erected in a vertical missile
Cqm	Missile yaw angle (the angle between the guidance reference plane and the missile pitch plane measured in the missile yaw plane)
Cqo	Own ship heading
CRO	Cathode-ray oscilloscope
CS	Clock sync: a signal from DRISS to guidance computer; also, signal from FSSS to command sequencer (two signals are not related)
CS	Command slew
CSI	Clock sync inhibit
CSSS	Command slew subsystem
cw	Control word
cycle time	Time required for a complete storage reference (6.4 microseconds)
cylinder	A set of tracks on the magnetic disk in vertical alignment with one another
DA	Digital to analog
DAC	Digital-to-analog converter
DAj	Fine erection torquing signal about horizontal reference axis (from fire control to the missile)
DASO	Demonstration and shakedown operation
DAv	Fine alignment torquing signal about the vertical axis (from fire control to the missile)
DCC	Digital control computer
DCC-ECDC	Digital control computer to equipment configuration display and control
DCNOK	Data check not OK

Term or Abbreviation	Stands For
DCOK(F)	Data check OK (fire)
DCOK(P)	Data check OK (prepare)
DCqo	Angular rate of change of own ship heading
DCR	Data check request
DDE	Disk drive electronics
DDR	Digital data request
DDU	Disk drive unit
DE	Discrete events
DEA	Digital erection assembly
DEio	Angular rate of change of own ship pitch
DEP	Data entry program: a program called into the DCC by a keyboard entry and used to enter data necessary to successfully fire a missile
DFCTE	Digital fire control test equipment
DGBC	Digital geoballistic computer
DIjk	Earth angular velocity about guidance cross-reference axis
DIk	Earth angular velocity about the polar axis
DIrk	Earth angular velocity about the horizontal reference axis
DIvk	Earth angular velocity about the vertical reference axis

Term or Abbreviation	Stands For
DIyk	Earth angular velocity about the north horizontal reference axis
DMho	Own ship speed
DRA	Digital read-in assembly
DRISS	Digital read-in subsystem
DTT	Digital transfer timing
EA	Electronics assembly
e(Bdaim)	Static correction for Bdaim
E(DAj)	Coarse erection torquing signal used to torque the guidance cross-reference axis
e(DAr)	Coarse erection torquing signal used to torque the horizontal reference axis
e(DAv)	Coarse alignment torquing signal about the vertical axis
EF	External function
EFT	External function translator
Eim	Missile pitch angle (the angle between the horizontal reference plane and the missile yaw axis measured in the missile pitch plane)
Eio	Own ship pitch
EOB	End-of-block (termination of digital information)
EOC	End-of-cylinder (termination of digital information and storage space)

Term or Abbreviation	Stands For
ER	Earth rate
ESS	Erection subsystem
ET	Events translator
EXF	External function
f	Force
F	Fuse, force vector used in missile steering, test fail
FA	Fine alignment
FAS	Fine alignment servo
FAT	Fine alignment torquer
FBD	Functional block diagram
FBS	Fine bearing servo
FC	Fire control
FCD	Functional circuit diagram
FCS	Fire control system
FCTE	Fire control test equipment
FCW	Fuze set control word
FLT/C	Flight control
FO	Firing order
FS	Fuze set
FSSS	Fuze set subsystem
GA	Gimbal assembly
GAC	Gimbal angle controller
GAMET	Gyro, accelerometer, misalignment and erection test
GAMM	Gimbal angle matching monitor
GARD	Gimbal angle runaway detector
GC, G/C	Guidance computer
GI	Guidance initialization sequence
GS	Guidance system
GSTE	Guidance system test equipment
GUPEL	Guidance correction coefficient
ICL	Intercomputer link
IDAS	Integrated data acquisition system
IFS	In-flight safety
IFW	Input fuze word
IMP	Integrated Monitoring Panel
I/O	Input/output
IPJP	Interpost Junction Panel
IRIG	Inertial reference integrating gyro
ITF	Intent-to-fire
ITOP	Integrated Test Operating Panel
I(U)	Accelerometer pulses
i(Ugm)s	Incremental accelerometer pulses
IV	Initial velocity

Term or Abbreviation	Stands For
KB, KBD, KYBD	Keyboard
LCC	Launch Control Center
LCP	Launcher Control Panel
LDCCT	Limited DCC test
Lxo	Own ship longitude
Lyo	Own ship latitude
MC	Missile compartment
MCA	Master clock assembly
MCC	Missile Control Center
MCP	Master clock patch
MCTSS	Master clock and timing subsystem
MD	Missile driver
MDA	Missilized driver assembly
MDF	Magnetic disk file
MDL	Manual disk load
MG	Middle gimbal
MM	Missile motion
MMC	Missile motion computer
MMIR	Missile motion input request
MMIV	Missile motion initial velocity
MMR	Missile motion request
MMSS	Missile motion subsystem
MTA	Master timer assembly

Term or Abbreviation	Stands For
MTRE	Missile test and readiness equipment
N	North
NC	Navigation Center
OA	Output axis
OAG	Optical alignment group
OD	Ordnance data
OG	Outer gimbal
OP	Ordnance pamphlet
ORU	Optical reference unit
OSCL	Own ship centerline
P	Attitude vector used in missile steering
PA	Prearm (signal to the missile reentry body that enables the arming of the warhead)
PB	Pushbutton
Pc	Normal clock pulse
PCO	Program checkout (word)
PCMP	POSEIDON command print program: a program that prints POSEIDON system information that exists on the MDF by processing the data for the desired printout
PCPP	Power Control and Protection Panel
Pd	Delayed clock pulse
PDP	Power Distribution Panel

Term or Abbreviation	Stands For
PEAC	Photoelectric autocollimator
PFI	Power Failure Interrupt (GC)
PIGA	Pulse integrating gyro accelerometer
PIP	Power Input Panel
PIPA	Pulse integrating pendulous accelerometer
PIW	POSEIDON input word
PL	Phase lock
PMMP	Preventive Maintenance Management Program
POW	POSEIDON output word
PSC	Parallel/serial converter
PSUP	POSEIDON supervisor program: the PSUP has overall responsibility for the control of the DCC except when the DCC is offline. The PSUP selects the proper subordinate programs (including the ITOP test executive) appropriate to the system mode of operation, configuration, and special commands from the keyboard.
pw	Pilot word
PWRSS	Power subsystem
RACE	Rate compensation electronics
RFS	Ready for sea

Term or Abbreviation	Stands For
RI	Reset inhibit
RNI	Read next instruction
SA	Simulator accelerometer
SAA	Simulator accelerometer assembly
SC	Start computer (signal from fire control to the missile)
Schedule	A structure used to define the order of processing computer tasks
SCP	Startup and Checkout Program (a special program stored in the MDF and always the first program loaded into the DCC when the DCC is bootstrapped from the disk. The SCP checks the ability of the DCC to function properly, thereby providing confidence in the DCC after the transition from offline to online.)
SCP	Supervisor's Control Panel
SDR	Serial data register
SE	Support equipment
SETS	Simulated environmental test signal
SFD	Scale factor differential
SFE	Scale factor error
SG	Servo group
SGSS	Servo group subsystem
SGTM	Spare guidance temperature monitor

Term or Abbreviation	Stands For
SHIPJP	Ship Junction Panel
SINS	Ship inertial navigation system
SIO	Store input/output in guidance computer
SLDCCT	Supplementary limited DCC test
SLS	Selective stop
SMP	Standard maintenance procedure
SMP	Servo Maintenance Panel
SMT	Short memory test
SOB	Start of block (MDF operations)
SOP	Standard operating procedure
SPALT	Special projects alteration
SQ	Condition of readiness
sr	Slant range reference axis in a plane 45° above the horizontal plane and in the downrange direction, or quantities measured along or about this axis
sv	Slant vertical reference axis in a plane 45° below the horizontal plane and in the downrange direction, or quantities measured along or about this axis
sw	Switch
swb, swbd	Switchboard

Term or Abbreviation	Stands For
sync	Synchronization
tac	Tactical
tach	Tachometer
tact	Tactical
TARE	Tape read program
Task	A set of instructions and constants which performs a maintenance, diagnostic, training, testing, or tactical function
TC	Temporary change
T/C	True/complement
TCR	Test code request
TDISS	Test instrumentation and data acquisition interface subsystem
TDUM	Training without guidance, or dummy fire program
TESS	Test subsystem
TG	Torque generator
TI	Test instrumentation
TICL	ICL command transfer program: a program that controls the transferring of data between the two MDFs or between the two DCCs
TMPS	Temperature monitor power supply
tng	Training
TO	Time zero (computer starts steering calculations and accelerometer outputs are fed to the computer)

Term or Abbreviation	Stands For
Tp 1 through Tp 17	Bit-time 1 through bit-time 17 (the basic timing signals from the MCTSS)
TVC	Thrust vector control
TWIG	Training with guidance
TWOG	Training without guidance
(Ugm)s	Missile linear launch velocity with respect to the primary inertial reference frame
Uhxgm	Eastward missile linear launch velocity
Uhxo	Own ship eastward velocity
Uhygm	Northward missile linear launch velocity
Uhyo	Own ship northward velocity
(Ujgm)k	Missile linear velocity at launch along the guidance cross-reference axis with respect to the Earth frame
(Urgms)k	Missile linear launch velocity along the horizontal reference axis with respect to the Earth frame
(Usrgm)k	Missile linear launch velocity along the sv reference axis with respect to the Earth frame
(Usvgm)k	Missile linear launch velocity along the sv reference axis with respect to the Earth frame
(Uvgms)k	Missile linear launch velocity along the vertical axis with respect to the Earth frame
Uvo	Own ship vertical velocity
V/N	Verb/noun (keyboard use)
VMB	Vernier mode bypass (guidance computer)
VMI	Vernier mode initiate (guidance computer)
WAG	Write address generator (MDF operations)
WCO	Weapons control officer
WNDE	Wind and density program; a program used to determine grid points for ballistic wind and air density entries
WSRT	Weapon system readiness test
ZA	Zero address
ZAS	Zero address sequence
Zm	Missile roll axis, or quantities measured along or about this axis
Zo	Own ship roll
Zvm	Missile yaw angle, missile vertical; missile roll (see Zm) with missile horizontal
1SQ	Final degree of readiness before launch
1SQ program	The program that makes final checks and adjustments to the missile before firing

INDEX

A

- Acceleration measurement subsystem, 2-27
- Accelerometers, 2-20 to 2-22
- Adjustable mount assembly, 8-8 to 8-9
- Administrative procedures, 9-1 to 9-44
  - calibration recall program, 9-42 to 9-43
  - equipment alterations, 9-41 to 9-42
    - ordnance alterations (ORDALTS), 9-42
    - ship alterations (SHIPALTS), 9-42
    - strategic systems project alterations, (SPALTs), 9-41 to 9-42
  - Navy Maintenance and Material Management System, 9-10 to 9-23
    - Intermediate Maintenance Activity Maintenance Management Subsystem (IMMS), 9-20
    - Maintenance data collection subsystem (MDCS), 9-18 to 9-20
    - organizational responsibilities, 9-20 to 9-23
      - commanding officer, 9-20 to 9-21
      - department head, 9-21
      - departmental assistant, 9-21
      - division officer, 9-22
      - executive officer, 9-21
      - maintenance personnel, 9-22 to 9-23
      - 3-M coordinator, 9-21
      - work center supervisor, 9-22
    - Planned Maintenance System, 9-10 to 9-17
      - cycle PMS schedule, 9-16
      - department master PMS manual, 9-11
      - Maintenance Index Page (MIP), 9-13

- Administrative procedures—Continued
  - Navy Maintenance and Material Management System—Continued
    - Planned Maintenance System—Continued
      - Maintenance Requirement Card, 9-13
      - PMS feedback report, 9-13
      - quarterly PMS schedule, 9-16
      - use of PMS documentation, 9-17
      - weekly PMS schedule, 9-16 to 9-17
      - work center PMS manual, 9-11 to 9-12
  - publications, 9-1 to 9-10
    - changes to publications, 9-4
      - types of changes, 9-4
    - classified publications, 9-5
    - Electronics Installation and Maintenance Books, 9-4 to 9-5
    - general instructions for completing a TFR, 9-8 to 9-10
      - section 1 (general), 9-8
      - section 2 (failed item), 9-8 to 9-9
      - section 3 (corrective maintenance accomplished by), 9-9
      - section 4 (if new item installed, identify), 9-9
      - section 5 (documentation/training material), 9-9
      - section 6 (software problem), 9-9
      - section 7 (narrative), 9-9 to 9-10
    - NAVSHIPS publications, 9-4
    - NAVSHIPS' technical manual, 9-4
    - Navy Directive System, 9-3 to 9-4
      - identification, 9-3 to 9-4

- Administrative procedures—Continued
  - publications—Continued
    - ordnance data, 9-2
    - ordnance pamphlets, 9-1 to 9-2
      - Ships Technical Publication System (STEPS) Ordnance Index T0751-AD-1DX-010, 9-1 to 9-2
    - Special Weapons Ordnance Pamphlets (SWOPs), 9-5 to 9-6
    - SWS and FBM weapon document requirements list (DRL), 9-2 to 9-3
    - TFR form distribution, 9-7 to 9-8
    - trouble and failure reports (TFR), 9-6
  - summary, 9-44
  - supply, 9-23 to 9-41
    - cognizance symbols, 9-24 to 9-25
    - equipment index, 9-35
    - job index, 9-35
    - job schedules, 9-35 to 9-40
    - job summary, 9-35
    - material identification, 9-23
    - material procurement, 9-28
    - Military Standard Requisitioning and Issue Procedure (MILSTRIP), 9-28 to 9-33
      - mandatory turn-in repairables, 9-32 to 9-33
      - requisition documents, 9-31 to 9-32
    - nomenclature, 9-25
    - organization, 9-33 to 9-35
    - other sources of identification data, 9-25 to 9-26
      - drawing numbers, 9-26
      - manufacturer's part numbers, 9-25
      - markings, 9-26
      - nameplates, 9-25 to 9-26
      - serial numbers, 9-25
    - PMMP feedback system, 9-40 to 9-41
    - PMMP planning/checkoff sheets, 9-40
    - Preventive Maintenance Management Plan (PMMP), 9-33
    - special material identification code (SMIC), 9-25

- Administrative procedures—Continued
  - supply—Continued
    - stock and control numbers, 9-23 to 9-24
      - national stock numbers, 9-23 to 9-24
      - NATO stock numbers, 9-24
      - Navy item control numbers, 9-24
    - supply publications, 9-26 to 9-28
      - Afloat Shopping Guide (ASG), 9-28
      - Coordinated Shipboard Allowance List (COSAL), 9-28
      - Management List-Navy (ML-N), 9-26
      - Master Cross-Reference List (MCRL), 9-26 to 9-27
      - Master Repairable Item List (MRIL), 9-27 to 9-28
  - weapons systems logs, 9-43 to 9-44
    - general FBM log requirements, 9-43 to 9-44
    - log forms, 9-43
- Alignment control console, 8-10
- Alignment periscope, 8-10
- Alignment subsystem, 3-19 to 3-21
- Angular motion, 2-3 to 2-5
- AN/URM-90, 6-19 to 6-20
- AN/USM-281, oscilloscope, 6-20 to 6-23
- Arithmetic section, 4-17 to 4-19
- Autocollimation, 8-4 to 8-5

B

- Ballistic shell subsystem, 7-14 to 7-15
- Bridge circuits, 6-19
- Boost phase, 7-17 to 7-19
- Bootstrap section, 4-6 to 4-8

C

- Calibration recall program, 9-42 to 9-43
- Changes to publications, 9-4
- Channelized operations, 3-1 to 3-2
- Classified publications, 9-5
- Cognizance symbols, 9-24 to 9-25
- Collimation, 8-4
- Command slew subsystem, 3-15 to 3-16
- Computer programs, 4-23 to 4-26

Computer subsystem, 2-30 to 2-34
Computing coordinate system, 1-17
Control and display subsystem, 3-8 to 3-15
Control section, 4-8 to 4-15
Coriolis effect, 2-5 to 2-6
Cycle PMS schedule, 9-16

D

Data transfer operations, 4-57 to 4-67
DCC-ECDC, 4-26 to 4-30
Degrees of freedom, 2-14 to 2-20
Detailed analysis (electro-optical), 8-12 to 8-17
Development phase, 7-19 to 7-21
Differential voltmeter, 6-15 to 6-18
Digital control computer group, 3-26 to 3-35
Digital geo-ballistic computer and magnetic disk file, 4-1 to 4-67
  computer programs, 4-23 to 4-26
    program categories, 4-24
      program and data storage, 4-26
      program function, 4-26
      PSUP program, 4-24 to 4-26
      subprograms, 4-26
  DCC-ECDC, 4-26 to 4-30
    functional description, 4-27 to 4-30
  DCC functional description, 4-1 to 4-23
    DCC instruction words, 4-1 to 4-5
      execution address modification, 4-4 to 4-5
      instruction word format, 4-4
    DCC mechanization, 4-5 to 4-23
      arithmetic section, 4-17 to 4-19
      bootstrap section, 4-6 to 4-8
      control section, 4-8 to 4-15
      DCC manual control and display, 4-6
      input/output section, 4-19 to 4-23
      memory section, 4-16 to 4-17
  magnetic disk file (MDF), 4-30 to 4-67
    functional description, 4-31
      disk drive unit (DDU), 4-37 to 4-48
      disk pack, 4-31 to 4-37
      MDF controller, 4-48 to 4-52

Digital geo-ballistic computer and magnetic disk file—Continued
  magnetic disk file (MDF)—Continued
    general description, 4-30 to 4-31
      disk drive unit (DDU) 4-30
      disk pack, 4-30
      MDF controller, 4-31
      MDF-DCC configurations, 4-31
    MDF operations, 4-52 to 4-67
      access operations, 4-53 to 4-57
      data transfer operations, 4-57 to 4-67
      manual controls, 4-52 to 4-53
Disk drive unit (DDU), 4-30, 4-37 to 4-48
Disk pack, 4-30, 4-31 to 4-37
Documentation, POSEIDON weapon system, 5-1 to 5-2

E

Earth-fixed coordinate system, 1-12
Electrical meters, 6-11 to 6-12
Electronics Installation and Maintenance Books, 9-4 to 9-5
Environmental control subsystem, 2-36
Equipment alterations, 9-41 to 9-42
Equipment index, 9-35
Erection subsystem, 3-21 to 3-22

F

Fire control system general maintenance and testing, 5-2 to 5-3
Flight-control subsystem, 7-6 to 7-13
Frames of reference, function of the, 1-18

G

General FBM log requirements, 9-43 to 9-44
General test equipment, 6-10 to 6-23
Geophysical properties, 2-5 to 2-7
Gimbal coordinate system, 1-17
Glossary, AI-1 to AI-8
Gravity, 2-6 to 2-7
Guidance coordinate system, 1-15 to 1-18
Guidance orientation, 2-22
Guidance subsystem, 7-6

Gyro elements, basic, 2-9 to 2-14
Gyroscopes used in FBM guidance, 2-7 to 2-20

H

Handtools, 6-9
How POSEIDON guidance works, 2-22 to 2-25

I

Identification data, other sources of, 9-25 to 9-26
Inertial devices and Mk 3 guidance, 2-1 to 2-38
- accelerometers, 2-20 to 2-22
  - basic accelerometer, the, 2-20 to 2-21
  - guidance orientation, 2-22
  - pulse integrating pendulous accelerometer (PIPA), 2-21 to 2-22
- gyroscopes used in FBM guidance, 2-7 to 2-20
  - basic gyro elements, 2-9 to 2-14
    - precession, 2-10 to 2-14
    - rigidity, 2-9 to 2-10
  - basic properties of gyroscopes, 2-8 to 2-9
  - degrees of freedom, 2-14 to 2-20
    - effect of mechanical drift, 2-14 to 2-15
    - keeping the gyro vertical, 2-15
    - one degree-of-freedom gyro, 2-15
    - rate gyros, 2-15
    - rate integrating gyro, 2-18 to 2-20
    - rate-of-turn gyro, 2-15 to 2-17
    - two degrees-of-freedom gyros, 2-14
- how POSEIDON guidance works, 2-22 to 2-25
  - stable platform, the, 2-23 to 2-25
    - gimbal servo loops, 2-25
    - orienting the platform, 2-24 to 2-25
- inertial devices, 2-1 to 2-2

Inertial devices and Mk 3 guidance—Continued
- Mk 3 guidance system, 2-25 to 2-38
  - acceleration measurement subsystem, 2-27
    - PIP, 2-27
    - serial coder, 2-28
  - computer subsystem, 2-30 to 2-34
    - PGC functional description, 2-32 to 2-34
    - PGC programming, 2-31 to 2-32
  - environment control subsystem, 2-36
  - inertial reference subsystem, 2-27
    - gimbal servo loop operation, 2-27
  - Mk 3 guidance maintenance, 2-37 to 2-38
    - maintenance levels, 2-37
    - temperature requirements, 2-37 to 2-38
  - power supply subsystem, 2-36
  - resolver subsystem, 2-29 to 2-30
    - gimbal angle resolvers, 2-29 to 2-30
    - P and F vector conversions, 2-30
    - P and F vectors, 2-30
  - system description, 2-25
  - timing subsystems, 2-34 to 2-36
    - oscillator, 2-35
    - timing reference generator, 2-35 to 2-36
- motion, 2-2 to 2-7
  - angular motion, 2-3 to 2-5
    - centrifugal and centripetal forces, 2-4 to 2-5
    - moment of inertia, 2-4
  - geophysical properties, 2-5 to 2-7
    - Coriolis effect, 2-5 to 2-6
    - gravity, 2-6 to 2-7
  - laws of motion, 2-2 to 2-3
    - inertia, 2-3
    - momentum, 2-3

Inertial reference subsystem, 2-27

Initiation of ignition and separation events, 7-6

Input/output section, 4-19 to 4-23

Instruction word, DCC, 4-1 to 4-5

Integrated data acquisition subsystem M35, 1-9 to 1-10
Intermediate Maintenance Activity Maintenance Management Subsystem (IMMS), 9-20

J

Job index, 9-35
Job schedules, 9-35 to 9-40
Job summary, 9-35

L

Launch phase, 7-17
Launching system, 1-8 to 1-9
Launching system, missile, 7-22 to 7-34
Laws of motion, 2-2 to 2-3
Light tube assembly, 8-10
Local geodetic coordinate system, 1-12
Log forms, 9-43

M

Magnetic disk file (MDF), 4-30 to 4-67
Maintenance data collection subsystem (MDCS), 9-18 to 9-20
Maintenance Index Page (MIP), 9-13
Maintenance philosophy and objectives, 6-23 to 6-26
Maintenance Requirement Card, 9-13
Manual control and display, DCC, 4-6
Master clock and timing subsystem, 3-7 to 3-8
Material identification, 9-23
Material procurement, 9-28
MDF controller, 4-31, 4-48 to 4-52
MDF operations, 4-52 to 4-67
MDF-DCC configuration, 4-31
Measurement functions, 8-5 to 8-8
Mechanization, DCC, 4-5 to 4-23
Memory section, 4-16 to 4-17
Military Standard Requisitioning and Issue Procedure (MILSTRIP), 9-28 to 9-33
Missile coordinate system, 1-17
Missile launcher control group Mk 18 Mod 2, 7-27 to 7-30
Missile launcher tube Mk 12 Mod 0, 7-22 to 7-26
Missile motion subsystem, 3-22 to 3-25
Missile subsystems, POSEIDON, 7-2 to 7-15
Missile support group Mk 2 Mod 0, 7-26 to 7-27
Missile test and readiness equipment Mk 6, 1-8
Missile test and readiness equipment Mk 7, 1-10
Missilized operations, 3-1
Mk 3 guidance maintenance, 2-37 to 2-38
Mk 3 guidance system, 2-25 to 2-38
Mk 24 launching system (POSEIDON), 7-22 to 7-34
MLS summary, 7-34
Motion, 2-2 to 2-7
Multimeter AN/USM-123, 6-14 to 6-15
Multimeters, 6-12 to 6-14

N

Navigation coordinate systems, 1-10 to 1-15
Navigation system, 1-4
NAVSHIPS publications, 9-4
NAVSHIPS' technical manual, 9-4
Navy Directive System, 9-3 to 9-4
Navy Maintenance and Material Management System, 9-10 to 9-23
Nomenclature, 9-25

O

OAG equipment, 8-8 to 8-10
OP 3804, proper use of, 5-1 to 5-2
Optical alignment group, 3-16 to 3-19, 8-1 to 8-17
    OAG summary, 8-17
    optical alignment group, 8-5 to 8-17
        capabilities, 8-11
        detailed analysis (electro-optical), 8-12 to 8-17
        measurement functions, 8-5 to 8-8
        OAG equipment, 8-8 to 8-10
            adjustable mount assembly, 8-8 to 8-9
            alignment control console, 8-10
            alignment periscope, 8-10
            light tube assembly, 8-10
            PEAC table assembly, 8-9
            station assembly, 8-9

- Optical alignment group—Continued
  - optical alignment group—Continued
    - photoelectric autocollimator operational theory, 8-12 to 8-16
    - system description, 8-11 to 8-12
    - wedge drive assembly operation theory, 8-17
  - optical principles, 8-1 to 8-5
    - autocollimation, 8-4 to 8-5
    - collimation, 8-4
    - optical wedges, 8-3 to 8-4
    - polarized light, 8-4
    - reflection, 8-1
    - refraction of light, 8-1 to 8-2
    - total internal reflection, 8-2 to 8-3
- Optical reference unit coordinate system, 1-12
- Ordnance alterations (ORDALTS), 9-42
- Ordnance data, 9-2
- Ordnance pamphlets, 9-1 to 9-2
- Oscilloscopes, 6-20

P

- Patrol operations, 5-3 to 5-23
- PEAC table assembly, 8-9
- Photoelectric autocollimator operational theory, 8-12 to 8-16
- Planned Maintenance System, 9-10 to 9-17
- Platform coordinate system, 1-15 to 1-17
- PMMP feedback system, 9-40 to 9-41
- PMMP planning/checkoff sheets, 9-40
- PMS documentation, use of, 9-17
- PMS feedback report, 9-13
- Polarized light, 8-4
- Portable electric power tools, 6-9 to 6-10
- POSEIDON fire control system Mk 88
  - Mod 1, 3-1 to 3-35
    - general description, 3-1 to 3-2
      - channelized operations, 3-1 to 3-2
        - denote and assign, 3-1 to 3-2
      - missilized operations, 3-1
      - subsystems, 3-2
    - subsystem functional description, 3-2 to 3-35
      - alignment subsystem, 3-19 to 3-21
        - coarse alignment circuits, 3-20
        - fine alignment circuits, 3-20 to 3-21
        - rate compensation electronics assembly (RACE), 3-21

- POSEIDON fire control system Mk 88
  - Mod 1—Continued
    - subsystem functional description—Continued
      - command slew subsystem, 3-15 to 3-16
        - CSSS control loops, 3-15 to 3-16
      - control and display subsystem, 3-8 to 3-15
        - attack center indicating panel, 3-8 to 3-10
        - battery timers, 3-10 to 3-12
        - control console, 3-10
        - data flow control circuits, 3-10
        - operational data flow, 3-12 to 3-15
      - digital control computer group, 3-26 to 3-35
        - digital control computer, 3-26
        - digital control computer group, 3-29 to 3-30
        - digital control computer peripheral equipment, 3-26 to 3-29
        - digital readin subsystem, 3-30 to 3-33
        - modular locations, 3-33 to 3-35
      - erection subsystem, 3-21 to 3-22
        - analog erection assembly, 3-22
        - digital erection assembly, 3-21 to 3-22
        - rate compensation electronics assembly, 3-22
      - master clock and timing subsystem, 3-7 to 3-8
        - distribution timing circuit for test assemblies, 3-8
        - distributive timing circuits for tactical assemblies, 3-8
        - master clock assembly, 3-7
        - master timer assembly, 3-7 to 3-8
      - missile motion subsystem, 3-22 to 3-25
        - analog-to-digital converter/interlace circuit, 3-24 to 3-25
        - computing circuit, 3-24
        - missile motion computer, 3-23

- POSEIDON fire control system Mk 88 Mod 1—Continued
  - subsystem functional description—Continued
    - optical alignment group, 3-16 to 3-19
      - dynamic measurement, 3-18 to 3-19
      - reference measurement, 3-16 to 3-18
      - static measurement, 3-18
    - power subsystem, 3-2 to 3-5
      - power control and protection panels, 3-5
      - power input panel assembly, 3-5
      - special power supplies, 3-5
    - servo group subsystem, 3-25 to 3-26
      - input and output multiplexers, 3-25 to 3-26
      - input servo assemblies, 3-25
      - output servo assemblies, 3-25
    - temperature monitor power supply Mk 141 Mod 1, 3-5 to 3-7
      - monitoring circuits, 3-6 to 3-7
      - power supplies, 3-6
- POSEIDON fleet ballistic missile weapon system, 1-1 to 1-19
  - introduction, 1-1
  - POSEIDON missile weapon system concepts, 1-1 to 1-2
  - POSEIDON weapon system organization, 1-2 to 1-10
    - integrated data acquisition subsystem M35, 1-9 to 1-10
    - launching system, 1-8 to 1-9
    - missile test and readiness equipment Mk 6, 1-8
    - missile test and readiness equipment Mk 7, 1-10
    - navigation system, 1-4
    - POSEIDON fire control system, 1-4 to 1-8
    - POSEIDON missile, 1-8
    - ship system, 1-4
  - weapon system frames of reference, 1-10 to 1-18
    - guidance coordinate system, 1-15 to 1-18
      - computing coordinate system, 1-17
      - function of the frames of reference, 1-18
- POSEIDON fleet ballistic missile weapon system—Continued
  - weapon system frames of reference—Continued
    - guidance coordinate systems—Continued
      - gimbal coordinate system, 1-17
      - missile coordinate system, 1-17
      - platform coordinate system, 1-15 to 1-17
    - navigation coordinate systems, 1-10 to 1-15
      - Earth-fixed coordinate system, 1-12
      - local geodetic coordinate system, 1-12
      - optical reference unit coordinate system, 1-12
      - ship attitude coordinate system, 1-15
      - ship coordinate system, 1-12
      - ship inertial navigation system coordinate system, 1-12 to 1-15
- POSEIDON missile and missile launching system, 7-1 to 7-34
  - introduction, 7-1 to 7-21
    - functional operation, 7-15 to 7-21
      - boost phase, 7-17 to 7-19
      - development phase, 7-19 to 7-21
      - launch phase, 7-17
      - prelaunch phase, 7-16 to 7-17
    - physical description, 7-1 to 7-2
    - POSEIDON missile subsystems, 7-2 to 7-15
      - ballistic shell subsystem, 7-14 to 7-15
      - flight-control subsystem, 7-6 to 7-13
      - guidance subsystem, 7-6
      - initiation of ignition and separation events, 7-6
      - power generation and distribution, 7-3 to 7-6
      - propulsion subystem, 7-13
      - reentry subsystem, 7-15
      - reentry system fuzing, 7-3

- POSEIDON missile and missile launching system—Continued
  - missile launching system, 7-22 to 7-34
    - Mk 24 launching system (POSEIDON), 7-22 to 7-24
    - missile launcher control group Mk 18 Mod 2, 7-27 to 7-30
      - missile support group Mk 2 Mod 0, 7-26 to 7-27
      - missile launcher tube Mk 12 Mod 0, 7-22 to 7-26
      - Mk 24 functional operation, 7-30 to 7-34
      - pressurization system, 7-30
      - related equipment, 7-30
      - umbilical retractors Mk 1 and Mk 2, 7-27
  - MLS summary, 7-34
- POSEIDON weapon system operation, 5-1 to 5-23
  - patrol operations, 5-3 to 5-23
    - tactical launch procedures, 5-4 to 5-23
  - POSEIDON weapon system documentation, 5-1 to 5-2
    - procedural documentation, 5-2
    - proper use of OP 3804, 5-1 to 5-2
  - refit maintenance and testing, 5-2 to 5-3
    - fire control system general maintenance and testing, 5-2 to 5-3
    - post sea trail operations, 5-3
    - sea trial operations, 5-3
- Post sea trail operations, 5-3
- Power generation and distribution, 7-3 to 7-6
- Power subsystem, 3-2 to 3-5
- Power supply subsystem, 2-36
- Precautions in the use of meters, 6-18 to 6-19
- Precession, 2-10 to 2-14
- Prelaunch phase, 7-16 to 7-17
- Pressurization system, 7-30
- Preventive Maintenance Management Plan (PMMP), 9-33
- Procedural documentation, 5-2
- Program categories, 4-24
- Propulsion subsystem, 7-13
- Protective packaging, 6-23
- PSUP program, 4-24 to 4-26
- Publications, 9-1 to 9-10
- Pulse integrating pendulous accelerometer (PIPA), 2-21 to 2-22

Q

- Quarterly PMS schedule, 9-16

R

- Reentry subsystem, 7-15
- Reentry system fuzing, 7-3
- Refit maintenance and testing, 5-2 to 5-3
- Reflection, 8-1
- Refraction of light, 8-1 to 8-2
- Resolver subsystem, 2-29 to 2-30
- Rigidity, 2-9 to 2-10

S

- Sea trial operations, 5-3
- Servo group subsystem, 3-25 to 3-26
- Ship alterations (SHIPALTS), 9-42
- Ship attitude coordinate system, 1-15
- Ship coordinate system, 1-12
- Ship inertial navigation system coordinate system, 1-12 to 1-15
- Ship system, 1-4
- Soldering irons, 6-10
- Special material identification code (SMIC), 9-25
- Special Weapons Ordnance Pamphlets (SWOPs), 9-5 to 9-6
- Stable platform, the, 2-23 to 2-25
- Station assembly, 8-9
- Stock and control numbers, 9-23 to 9-24
- Strategic systems project alterations (SPALTs), 9-41 to 9-42
- Subsystem functional description, 3-2 to 3-35
- Supply, 9-23 to 9-41
- Supply publications, 9-26 to 9-28
- SWS and FBM weapon document requirements list (DRL), 9-2 to 9-3

T

- Tactical launch procedures, 5-4 to 5-23
- Temperature monitor power supply Mk 141 Mod 1, 3-5 to 3-7
- TESS basic operations, 6-2 to 6-8
- TESS general description, 6-2

Test equipment and maintenance, 6-1 to 6-26
  general test equipment, 6-10 to 6-23
    AN/URM-90, 6-19 to 6-20
    bridge circuits, 6-19
    differential voltmeter, 6-15 to 6-18
    electrical meters, 6-11 to 6-12
    multimeter AN/USM-123, 6-14 to 6-15
    multimeters, 6-12 to 6-14
    oscilloscope AN/USM-281, 6-20 to 6-23
    oscilloscopes, 6-20
    precautions in the use of meters, 6-18 to 6-19
    protective packaging, 6-23
  introduction to testing, 6-1 to 6-8
    TESS basic operations, 6-2 to 6-8
    TESS general description, 6-2
    test philosophy, 6-1 to 6-2
    types of tests, 6-1
  maintenance philosophy and objectives, 6-23 to 6-26
    maintenance levels, 6-24 to 6-26
    objectives, 6-23 to 6-24
    tools and test equipment, 6-26
  safety precautions, 6-9 to 6-10
    hand tools, 6-9
    portable electric power tools, 6-9 to 6-10
    soldering irons, 6-10
    test equipment, 6-10

Test philosophy, 6-1 to 6-2

TFR form distribution, 9-7 to 9-8

TFR, general instructions for completing a, 9-8 to 9-10

Timing subsystems, 2-34 to 2-36

Total internal reflection, 8-2 to 8-3

Trouble and failure reports (TFR), 9-6

U

Umbilical retractors Mk 1 and Mk 2, 7-27

W

Weapon system frames of reference, 1-10 to 1-18

Weapons systems logs, 9-43 to 9-44

Wedge drive assembly operational theory, 8-17

Wedges, optical, 8-3 to 8-4

Weekly PMS schedule, 9-16 to 9-17

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